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HINTS

FOR

COLLECTING INFORMATION

COMPILED

FOR

THE EXPEDITION

TO CHINA.

Ite nunc fortes, ubi celsa magni
Ducit exempla via ,—

Boethius.

915.1
H666

William Rushton, & Co. Printers, Calcutta.

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ADVERTISEMENT.

The very limited time which the compilers of the following sheets could command to prepare them for the Press, and the very few works of reference at their disposal, must be their apology for many imperfections and omissions. Their object is sufficiently expressed by the title page, and their efforts will be amply rewarded, if the information they have collected should be the means of adding to the vast stock of scientific facts which have recently been amassed by the labours of so many distinguished scientific travellers.

Not being quite sure how to give to every one his due, the compilers have left out all acknowledgments, disclaiming once for all every pretension to originality. They are convinced that those cultivators of science who may happen to recognize their own expressions in the following pages, will fully approve of the use which has been made of their property in promoting those objects to which their time and attention have been so successfully devoted.

Calcutta, 1st *May*. 1840.

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HINTS, &c.

The present expedition to China offers an opportunity for scientific research, and for the collection of general information as to the remarkable and little known countries about to be visited, that is too valuable to be neglected. The following general instructions have therefore been drawn up, with the view of pointing out to all those engaged in the expedition, who may have any opportunity for observation, the principal subjects on which it is desirable to collect information, and also what particulars it is most essential to observe and to record. Scientific men will be most usefully employed in following out their own pursuits in their own way, but from their habits of accurate observation, their remarks on subjects which have not been their peculiar study will still be of great interest; and the following hints may be useful to them as notes of what enquiries are most desirable. Those who are unaccustomed to scientific studies, may also be of great service as collectors, and the directions given below will be found a sufficient guide to make them valuable auxiliaries in the proposed enquiry.

The subjects of enquiry naturally arrange themselves under two general heads: First,—the physical sciences, including Geography and Hydrography, Meteorology, Magnetism, Zoology, Botany, Geology and Mineralogy.

Secondly,—The inhabitants of the countries visited. Their arts of life, peculiar manners, customs, and languages. The natural productions of the soil, manufactures and objects of commerce.

1.—The first and most obvious objects of enquiry for a maritime Expedition, are Geography and Hydrography.

GEOGRAPHY.

As the coast of China bears a great resemblance in position to that of the United States of North America, lying as it does to the extreme east of a great continent with an immense frozen tract to the north west, a very great similarity may be expected in the phenomena of both seas as influenced by climate. It would be interesting to know whether a permanent current like the Gulf Stream exists, and if so, its extent and direction. If not, what minor or partial currents may prevail and whether they are affected by the monsoons or perpetual.* The exact extent of the monsoon, and the usual direction of the winds beyond its limits should be observed. The extreme northern limit of typhoons is unknown; accurate observations on their extent, force, and duration, are required, in order to perfect the theory of storms.

The following questions contain a summary of the most important objects of Geographical enquiry :—

1. *Aspect.*

1. What is the general aspect of the country?
2. Mountainous or hilly?—Sharp peaks or rounded outlines?
3. Of the coast? Abrupt or shelving? Rocky or in cliffs?
4. Downs of sand? Low or flat?
5. Any active volcanoes? or traces of extinct ones? or their probable forms in the outline of the mountains?

2. *Surface.*

1. Is the surface level or undulating?
2. Has it a tendency to table lands, or steppes?
3. Is the soil rich or poor? loamy—sandy—boggy?

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* To ascertain this, bottles should be occasionally thrown overboard, containing a memorandum of latitude and longitude and the date. A little dry sand in the bottle will make it float upright. They should be carefully corked, and the cork dipped in melted pitch.

4. Are the plains fertile or barren? wooded or cultivated?
5. What its general capabilities?

3. *Physical Divisions.*

1. Note the chief divisions of the country.
2. Mark especially the line of separation of waters.
3. Trace the outlines of the principal basins of the chief rivers.
4. Group the country into basins as far as practicable; it will be found the simplest mode of describing it.
5. Trace also the limits of the secondary valleys comprising the tributaries to the main stream.
6. May they from position be called upper and lower basins?

8. Do distinct tracts of mountainous—hilly—flat—wooded—jungle—cultivated—sandy—marshy or barren, country exist? If so, note their limits generally.

4. *Mountains.*

1. What is the direction of the chief range, or ranges?
2. What is the general form of outline? (Describe while in sight, *not* from memory.)
3. What is the *estimated* height (if no measurement can be had) of the chief points; and also of the general range?
4. Are any of them snow-capped? (State the season.)
5. How far down does the snow extend? (Note north or south side.)
6. Are they wooded?—At what height does the wood finish?
7. At what height does vegetation cease?
8. Are the mountains in groups or masses? or detached?
9. Obtain bearings, by compass, of the limits of the range, and of all remarkable points, passes, gaps, &c.
10. Mark the chief mountain-passes, and note if they might be easily defended against an enemy.
11. What is their general structure?

5. *Rivers.*

1. What are the native names of the chief rivers?
2. Trace the general course of each; with its windings, if possible.
3. Does it receive many tributaries? note their names in order, from its sources, distinguishing on which side they join.
4. Is it navigable for large or small craft? and to what extent?
5. How far up does the tide reach? Is the current rapid? What its rate?
6. Does it flow by several outlets, or by one grand mouth to the sea?
7. Does it form a bar, or banks, or islands at its mouth?
8. What is the width of the river at its outlet? and at various points?
9. Is the river ever fordable? Name the chief fords.
10. Does it form cascades, or rapids, or occasionally inundations?
11. Does it at any season lose itself in sand, or otherwise not reach the sea?
12. Does it flow from a lake, or from other sources or springs?
13. What may be the probable elevation of its source above the sea? measured or estimated.
14. Is the bed of the river gravel, sand, or mud? Does it bring down much detritus?
15. What is the colour of the water? Does it retain it at any distance from land?
16. Is the river obstructed by islands, shoals, rocks, snags, or any obstacle to steam navigation.
17. Are its banks wooded? Is fuel easily procured?
18. Does it abound in fish? and in what species?
19. Is it navigated by native boats? and how far up?
20. Describe each affluent as a main stream, with its tributaries, marking the positionof junction, and the angle at which it joins its recipient.

6. *Lakes.*

1. What are the native names of the lakes?
2. What is the situation and extent of each?
3. What is its level, above or below the sea? How ascertained?
4. Is it formed by rivers or springs? or does it feed any river?
5. Is it of salt or fresh water? Is it said to rise and fall periodically?
6. What is its general depth of water?
7. Are there any vessels or boats upon it? and of what size?
8. Are its banks rocky and steep, or low? Are they wooded or barren?
9. Could fuel be readily procured? Does it offer facilities, or the contrary, to steam navigation?
10. Are its shores thickly inhabited? Are birds, fish, shellfish, &c., plentiful, and of what sort?
11. Are any marshes or ponds known, and where? Are they constant or periodical?

7. *Sea Coasts and Ports.*

1. Does the coast form gulfs, bays?
2. Promontories, peninsulas, capes, low points, &c?
3. Is it abrupt, bold, rocky? or low, flat, and shoal?
4. Are there currents along the coast? Note their force and direction.
5. Name the chief *ports* Are they secure harbours, or only open bays, or roadsteads for anchorage?
6. What is the depth of water, and what bottom for anchoring?
7. Is the port capable of containing many vessels? Does it offer facilities for repair?
8. Can water, provisions, and fuel be easily procured?
9. Note the time of high-water at full and change of moon, and rise and fall of tide; and direction and velocity of stream.

8. *Volcanoes and Mineral Springs, &c.*

1. Are any now active? or, are there traces of extinct volcanoes?
2. Give their position—height above the sea—and native names.
3. Does tradition or history record any eruption? at what date?
4. Was the eruption of fire, lava, scoriæ, water or mud?
5. Are earthquakes frequent? Are there records of any having occurred?
6. What were their effects? how far did they extend? any up-heaving or depression of land recorded?
7. Are many *mineral springs* known? Hot, tepid, or cold? (Note the temperature if possible). Are their waters used medically?
8. Do they form deposits? Siliceous or calcareous?

9. *Maps, Charts, &c.*

1. Do any charts of the coast, maps of the country, or partial surveys exist? Native or otherwise? What are their respective dates?
2. Are they believed to be accurate? Upon what scale?
3. Endeavour to map the country, starting, if possible, from a fixed point; if exact observations cannot be obtained; give compass bearings, and estimated heights and distances. (N. B. Heights may often be obtained by length of shadow, &c.; distance by velocity of sound, &c.) The scale of one inch to a geographical mile is recommended.
4. Take bearings of all remarkable objects in sight from any known station; as mountain-peaks, masses, gaps, towns, villages, forests, &c. &c., and transfer all to paper immediately; trust nothing to memory.
5. Preserve all original observations and do cuments relating to surveys; and make two or three copies of observations.

6. Obtain correct *native* names if possible, and keep to one standard of orthography. Mark all hearsay information with the initials of the informant. If a journey is made by night, or in foggy weather, trace it with coloured ink.

10. *Astronomical Observations.*

1. Are any positions astronomically determined? What reliance may be placed on them?
2. It is very important to obtain observations for the position of all capes, headlands, points, towns, villages, &c.; mountain peaks, passes, limits of range, &c.; lakes, sources, confluence and outlets of rivers; in short, of every remarkable object.
3. Endeavour to obtain the *latitude* by meridian altitude of the sun, or of a planet, or of a star, or of the moon.
4. *Lontigude*—by eclipses of Jupiter's satellites, especially by eclipses of the third and fourth satellite, when both immersion and emersion can be observed,—or by any other eclipse; by moon culminating stars; by occultations of fixed stars by the moon; by lunar distances from the sun, or a planet, or a star, always East and West when possible; by an altitude of the moon in the prime vertical; or by chronometers; state always by which method obtained, and what reliance may be placed on it.
5. Observations on the variation of the compass, and dip of the needle, are very important.

Instruments.

A repeating circle, or sextant of five inch radius; a pocket sextant; an artificial horizon; Kater's compass; two mountain barometers (Newman's make); and two thermometers, with a good pocket chronometer; are sufficient for all common purposes.

1. Keep an exact register of the barometer and thermometer.
2. What are the prevalent winds? What the periodical?

3. What the average fall of rain?
4. What the amount of evaporation, &c.?

Natural History.

1. Note the geographical distribution of man, animals, birds, fishes, insects, plants, &c.
2. Obtain information on all branches of Natural History, bearing in mind that the useful and practical is of more importance than the merely curious.

For detailed instructions, under each head, recourse should be had to the respective sources.

Ethnography.

1. Obtain vocabularies of the native language—phrases rather than single words. Keep to a fixed standard of orthography in writing them down: the sounds of the vowels in *father—there—ravine—mole—lunar*, are recommended as the most simple, and as being both English and European.
2. Note the habits, manners, customs, and amusements of the natives.
3. What notion have they of a Supreme Being? what of a future life? what, if any, their religious ceremonies?
4. What is their treatment of the aged, of the sick, and of children?
5. What seems to be the form of government? Is division of property recognized? Do they buy and sell land?
6 Do they trade or barter with each other, or with strangers?
7. Note the number of natives seen from day to day, distinguishing the sex, and children.
8. Are there many lunatics or idiots?
9. What is the usual form of feature? the shape of the skull? hair? colour? stature? bodily constitution?
10. Is plurality of wives common? are women without husbands frequent?
11. Have they any marriage ceremonies? how do they treat their wives?
12. Do they give proof of capacity for civilization?

13. May the natives be trusted as guides—as messengers—or to procure food?
14. What presents please them best?
15. What words or signs do they use when hostile? or when friendly?
16. What are their dwellings? What their chief articles of food?
17. What their disposition—savage or gentle; rash, hasty, or inoffensive? Are they disposed to receive instruction?
18. Are any cases of cannibalism reported? (N. B. To investigate strictly under what circumstances they occurred.)
19. Are the people said to be increasing or decreasing?
20. Does slavery exist? What is the condition of a slave?
21. What are their diseases? What their medical treatment?
22. Can the traveller point out the most probable mode of civilizing and benefiting the natives?
23. What traditions are current respecting the origin of the people?
24. Collect all information that can throw light on migration of nations.

N. B. The greatest forbearance and discretion are strongly recommended in all intercourse with the natives—never to allow an imaginary insult to provoke retaliation which may lead to bloodshed. It must be borne in mind their's is the right of soil—we are the aggressors.

HYDROGRAPHY.

The general feature of the continents and groups of islands on the globe have been pretty accurately determined, it only remains therefore to fill up the details, and to this interesting part of the subject the attention of the naval part of the expedition is particularly directed:

The Coasts of China are very imperfectly known, and many of the islands not at all. No opportunity should be lost of

making accurate charts; the soundings, directions of tides and currents, positions of harbours and anchorages, and all dangers, should be ascertained and recorded with the utmost care. If possible, accurate sketches should be made of all remarkable headlands and leading marks for roadsteads and harbours, inaccurate ones are better omitted. The longitude should be ascertained by observations on shore, whenever practicable. The Chinese names should be given in the Chinese character, as a pilot of the country can generally read them, and knows thereby what is required of him.

The existence of Coral Reefs should be carefully ascertained, and their extent noted—it is important to know the extreme northern limit of these formations.

A detailed account of how a survey should be carried on, cannot be expected in the limits of this pamphlet, but it may be observed that golden occasions are often lost from the want of knowing how much may be done with the means in our possession. Furnished with a boat, a sextant, and a lead line, a useful sketch may he made of a large anchorage in forty-eight hours. Great care should be taken that the stations are properly marked, or errors may creep in from one point being mistaken for another. A bucket of white wash affords a simple means of marking rocks, and generally some tree or bush may be selected, for the same purpose. The absolute distances may be determined either by measuring a base with a stretched line or rods; by using the height of the *truck* as a base and observing the angle it subtends from various stations: or by firing guns and noting the interval of time betwixt the flash and report. A simple rule for the distance is $c \times t = d$. d being the distance; t the interval in seconds; and c 1100 feet, to be increased half a foot for every degree of Fahrenheit above the freezing point. Several guns should be fired and the mean interval taken, as it should be borne in mind that a greater error in the distance will arise from an error in the interval of time, than from an error in the constant c.

The correct position of one well defined point is of great importance. A sextant, artificial horizon, watch, and a clear night

will go far to settle the latitude within narrow limits. Stars are easily observed by reflection, and present the advantage of offering many opportunities the same evening. Such as have nearly equal altitudes towards the north and south should be selected in order to eliminate errors in the instrument, in the habit of observing, and of refraction.

The observation should be commenced ten minutes before the transit, and continued until ten minutes after; the separate observations being reduced to the time of transit by the usual formula. The error of the instrument should be determined both on the preceding and following days, and the observations for this purpose preserved.

If the sun be preferred, the same course should be followed the error being determined at the time.

If the sea horizon be used, let one observer be on deck and another in the main top.

Divide the difference of the two resulting latitudes excluding the dip, by the difference of the square roots of the heights of the eye, the quotient multiplied successively by the square roots of the height will give the dip for each observer—the resulting latitudes will of course be equal.

The correct determination of the longitude will depend chiefly on an accurate account being kept of the rate of the chronometers. No pains therefore should be spared to obtain sights at every place where the ship anchors. I consider equal altitudes the most eligible method of obtaining the time with a sextant, but absolute altitudes can be used if more convenient, —care only in this case should be taken that the objects are taken when the sun has the same azimuth, so that the errors in the time arising from any error in the latitude, may be constant. It would be desirable that on the first day after arrival, and the last before quitting, sights should be taken both before and after noon; and the mean of the errors deduced be used. The difference of time from the last place where sights were obtained is to be registered, leaving the absolute longitude to future consideration. Lunar distances taken with great care; the cor-

rect time accurately; noted, the altitudes calculated; and attention paid to all the minor corrections, will give valuable results. For this purpose select a star on each side of the moon, at nearly equal distances, and varying their distance at nearly the same rate. Without attention to these details, hundreds of distances will give but an approximation to the truth. Occultations when they occur should be carefully observed; and those possessing a transit will not, when occasion serves, omit moon culminating stars.

Having settled the position, let them note

1st.—The directions for sailing into and from the port. These should include the general appearance of the coast, and marks for the harbour; dangers, and the leading and cross marks for avoiding them. How pilots are procured, and if necessary. Prevailing winds;—if periodical, the time of commencement and termination.

2nd.—Best anchorage both in the port and outside. Whether there is anchorage in the narrowest part of the channel; landing places, and whether ship's-boats can land. Whether room for a fleet or not. If egress in all winds. Best position for blockading or watching an enemy lying in the port. Direction and velocity of tides or current.

3rd.—Means of obtaining wood, water and refreshments. If your own boats can water the ship, and in what quantity obtained. Whether provisions can be obtained, and if the market can be relied on for a large supply. Ditto Naval stores. If watering places are commanded by any fortifications, and whether the ship can command the watering place.

4. Fortifications—their nature, extent, and strength. Probable number of men required to garrison them—whether they command the whole anchorage. Whether ships can act against them. Proper places for landing troops, &c.

5. As the expedition will be navigating in nearly unknown seas, it will be proper to sound with the deep sea lead at stated intervals; also to compare the temperature of the sea with that of the air. In low latitudes the surface water is generally hot-

ter than that below, and it has been a general remark that the temperature sinks when the water shoals. This is a subject of great interest to navigators.

In all cases distinguish between one's own observation, and information obtained from others.

TIDES.

The use of continued observations of tides at the same place is to determine the dependence of the time, height, and other circumstances of high and low water, upon the places and distances of the sun and moon.

Particular tides are affected by considerable anomalies and uncertainties, but in the averages of a long series of observations general rules consistent with theory prevail with great constancy. The object of observation should be to verify these rules, and to determine the constant quantities which enter into them. For this purpose we have to attend to

1.—*The Establishment of the Place.*

The interval at which high water follows the moon's meridian passage at a given place varies from day to day (being effected by the semi-menstrual inequality.)

The *Vulgar Establishment* is the duration of this interval on the day of new or full moon.

The *Corrected Establishment* is the mean duration of this interval.

2.—*The Law of the Semi-menstrual inequality.*

In the mean state of the parallaxes and declinations of the sun and moon, the interval at which high water follows the moon's meridian passage is affected by an inequality depending on the moon's distance from the sun, and going through all its changes in a half lunation: this is the *semi-menstrual inequality.*

The inequality is theoretically the same at all places; and therefore in simple tides at every place the law and amount of

the inequality of the interval of the tide and moon's passage during a half ? lunation is the same.

It is desirable to verify this rule; and if exceptions occur to examine the circumstances of them.

3.—*The Age of the Tide.*

The circumstances of each tide do not correspond to the places of the sun and moon at the time of the tide, but at a time one, two, or three days earlier; this distance of time is called *the age of the tide,*

Two such circumstances may be especially noted.

1st.—The spring tide or *highest* high water is not on the half day of new or full moon, but at a certain tide on some later half day.

2nd.—The interval of tide and of moon's passage has not its mean value on the half day of new or full moon but for a certain tide of some later half day.

The distance of time from the new or full moon to the time when the interval of tide and moon's passage has its mean value is the age of the tide.

4.—*The Diurnal Difference of the Tide.*

It appears from theory that in simple tides there should be a difference in the height of the two high waters on the same day: in such cases during one part of the year the morning tide, during another part the evening tide, is the higher.

It is desirable to verify this diurnal difference and to determine its amount at particular places.

5.—*The Peculiarities of the Tide at Particular Places.*

At many places the tides are compounded of two simple tides which arrive by different paths: this composition may give rise to new circumstances.

For instance the diurnal difference may be obliterated: or it may be accumulated so as to produce only one tide in twenty-four hours.

6,—*The Effect of the Changes of Parallax and Declination of the sun and moon.*

These changes may effect both the height and the time of

high water. Their effect can only be detected by a considerable series of good observations carefully discussed.

Observers of the Tides should record particularly, the Time and height of high water.

The time and height of low water.

The direction and force of the wind.

The height of the barometer and thermometer.

The direction and velocity of the stream of flow and ebb; at what hour, (with respect to the time of high and low water,) slack water occurs.

The height must be measured from some fixed mark, which should be described accurately. It should also be stated, whether the time be *mean* or *apparent*, and how obtained.

The simplest method of observation appears to be by means of a staff carefully graduated, connected with a float, and working through a collar where the height is read off.

The staff must be kept in a vertical position by means of friction rollers: the float should be in a chamber to which the water has access through a small opening to do away as much as possible with the action of the waves. The observer should note the height every minute, for half an hour before the expected time of high water, and continue until there can be no doubt tkat the time is past. This is rendered necessary, as the water often rises and falls by jerks, rendering the method of equal heights uncertain.

When it is intended to make a long series of observations it is of course desirable to adopt every precaution to ensure accuracy; but the *Establishment* of a Port may be determined without any expensive apparatus.

When the rise is large and the tide little subject to irregularity a short period will determine the phenomena pretty accurately; but in the open ocean the rise is small and the tide often hangs half an hour at high water, rendering a longer series of observations necessary.

It is desirable that those who have the opportunity should combine to execute a detailed description of the tides through some short extent of coast.

To determine the *Corrected Establishment* the observation should be continued at least fifteen days.

To detect the *Diurnal Difference* observation should be made when the moon is at her greatest declination or a few days later; not when she is on the equator.

METEOROLOGY.

Meteorology is one of the most complicated of all the physical sciences, and that in which it is necessary to spread our observations over the greatest extent of territory, and the greatest variety of local and geographical positions. It is only by accumulating data from the most distant quarters, and by comparing the affections of the atmosphere at the same instant at different points, and at the same point at different moments, that it is possible to arrive at distinct and useful conclusions. Hence arises the necessity of procuring regular series of observations made on a uniform system, and comparable with themselves and with each other, by observers at different stations, and of multiplying the points of observation as much as possible over the interior surface of continents—along sea coasts—in islands—and in the open ocean.

General Recommendations and Precautions.

The continuity of observations ought to be interrupted as little as possible by changes in the adjustments of instuments—in their places—exposure—mode of fixing—or of reading off and registering them. Whenever any alteration in these or any other particulars takes place, especially such as are likely to affect the zero points, or otherwise to influence the mean results, it should be noticed in the register.

2. So far as possible, registers should be complete—but if by unavoidable circumstances of absence, or from other causes, blanks occur, no attempt to fill them up by general recollec-

tion, or by the apparent course of the numbers before and after, should ever be made.

3. The observations should, if possible, all be made by one person—but as this may often be impracticable, the principal observer should take care to instruct one or more of his family how to do it, and should satisfy himself by many trials that they observe alike.

4. The entries in the register should be made at the time of observation, and the numbers entered should be those actually read off on the respective scales of each instrument, on no account applying to them previous to entry any sort of correction; as for instance for zero, for temperature, capillarity, &c. All these and the like corrections, being matter of calculation and reasoning from other observations, are to be reserved till the final discussion of the series, and for separate determination and statement.

5. If copies be taken of the registers, they should be carefully compared with the originals by two persons, one reading aloud from the original and the other attending to the copy, and then exchanging parts, a process always advisable whereever great masses of figures are required to be correctly copied.

6. A copy so verified, or the original (the latter being preferred) signed by the observer, should be transmitted regularly to some central point where the observations can be made available towards the improvement of our knowledge of the science.

7. The register of every instrument should be kept in parts of its own scale, as read off; no reduction of Foreign measures or degrees, to British being made—but it should of course be stated *what* scale is used in each instrument.

Of the Times of Observation and Registry.

Meterological observations should be made and registered at stated and regular hours.

The barometer being the most important of all the instruments used, suggestions as to the times of observing it, will serve as well for the others.

Conclusions could be most perfectly and expeditiously obtained by hourly observations throughout the year; but as such a course of unremitting labour cannot be looked for on the present occasion, it is necessary to select periods at longer intervals, calculated to embrace the extremes of the periodical oscillation to which the pressure of the atmosphere is subject, and also to ensure uniformity of system.

The following scheme is laid down by the Council of the Royal Society, to be followed out in the magnetic observatories lately established, and observers are invited to follow the same plan as most likely to lead to beneficial results.

The hours of 3 A. M., 9 A. M., 3 P. M., and 9 P. M. nearly coincide with the daily maxima and minima of the height of the mercurial column over a great part of the globe; therefore at those hours the height should be registered.

Should the hour of 3 A. M. be inconvenient, an effort should be made to include it on the days of new and full moon, and at the quadratures, as it must be borne in mind that in these investigations the night is as important as the day.

It is recommended that one day in each month be set apart for a most scrupulous and accurate registry of the state of the barometer and thermometer; the direction and force of the wind; the quantity, character, and distribution of the clouds, and every other particular of weather throughout the whole twenty-four hours of those days, and the adjoining six hours of the days preceding and following. The day recommended is the 21st, noticing that if the 21st fall on Sunday, the observations are to be deferred till the next day, the 22d.

At any rate, let this be done on the 21st March, June, September and December with the same reservation as to Sunday.

Of Meteorological Instruments, and first of the Barometer and its attached Thermometer.

The Barometer is the most important of all Meteorological instruments. Its office is to measure the actual pressure of the atmosphere on a given horizontal surface at the time and

place of observation. Its fluctuations are observed to have considerable relation to changes in the weather, and especially of the wind. Hence its use as a weather glass.

A Barometer should be examined, before setting it up, for air-bubbles in the tube, and for the existence of air above the mercury in the upper part of the tube. This is done by gently inclining the instrument either way from the horizontal position a little up and down; when air-bubbles, if large, will be seen to run to and fro, and must be evacuated by inverting the instrument and by gentle blows on it with the hand, driving them up into the cistern. If this cannot be done, the instrument is useless. If air exists to an objectionable amount *above* the quicksilver, it will not tap *sharp* against the upper end of the tube when the barometer is quickly inclined from a vertical position so as to make the mercury rise above its level, nearly to the top, and then gently *jerked* lengthways and backwards. If the blow is puffy and dead, or is not heard at all, the amount of air must be considerable, and may be expelled by inversion.

In fixing the barometer, choose a good light near a window, but not exposed to sunshine, in a retired apartment, little liable to sudden changes of temperature or to drafts of wind. Adjust the tube to a vertical position by a plumb-line, and fix it so as never to shift from that position. Before reading off, give a few taps on the instrument, enough to make the upper end of the column of quicksilver *shake* visibly, as the mercury is apt to adhere to the glass and give erroneous readings. In reading, bring the index always opposite to one part. The correct part to choose is the summit of the convexity of the mercury, to which the index should be made a tangent, but if this be difficult to hit, either from the construction of the index or the want of a proper fall of light, the line of junction of the mercury and glass may be taken. In that case the tapping should never be omitted. Whichever mode of reading is once adopted should be stated, and always adhered to. A piece of white paper placed behind the upper part of the tube will generally enable any one to read off by the convexity of

the quicksilver. In placing the index, notice whether it appears to shift a little up and down as the eye is raised or depressed. This is called Parallax, and is a source of uncertainty to be avoided by placing the eye in reading always on the *exact level* of the top of the mercurial column.

Barometric observations require corrections of three kinds, and to render them available and comparable with others, it is necessary that their amount should be ascertained and distinctly stated. The first is called the Zero Correction. It includes several subordinate corrections arising from different sources, such as that originating in a faulty placing of the scale of inches, that due to the capillary depression of the Mercury in the glass tube, and the constant part (which at a fixed station is nearly the whole) of the depression arising from the presence of air or vapour in the upper part of the tube.

To determine the zero correction, the barometer must be compared with a standard instrument, such as that at the Royal Observatory for instance, or some other which has been compared with it, or with some standard of equal authority. Such comparison ought never to be omitted before forwarding the Barometer to its place of destination, nor should any opportunity be neglected of comparing it, when fixed in its place, with a good portable Barometer. In making such comparisons, all that is necessary is to record the readings of both the instruments, after at least an hour's quiet exposure, side by side, that they may have the same temperature. If compared by two observers, each should read off his own Barometer in his usual manner, and each should take a mean of several readings, then each should verify the other's result. By this means the zero of one standard may be transported over all the world, and that of all others compared with it ascertained.

The amount of the zero correction is often very large, as two or three-tenths of an inch, but its influence on the mean results of recorded observations, falls wholly on the determination of the heights of the station of observation above the mean level of the sea, and affects little, if at all, any conclusions of a meteorological nature which may be deduced from

them. Hence, if proper care be taken to preserve a Barometer, once set up, immoveable, a long and regular series of observations with it has a value independent of any knowledge of this element, and it is fortunate that this is the case, as the zero correction is one extremely difficult to determine exactly *a priori.*

In transporting a *compared* Barometer to its place of destination, great care is necessary. It should always be carried *upright* or considerably inclined, and *inverted,* and over all rough roads should be carried in the hand, to break the shocks to which it would otherwise be exposed. Strapped obliquely across the shoulder of a horseman, it travels securely and well, and with common care in this mode of transport, its zero runs no risk of change.

The next correction, and the most important of all, is that due to the temperature of the Mercury in the Barometer tube at the time of observation. To obtain this, every Barometer requires to have attached to, or fixed very near it, a Thermometer, called the *attached* Thermometer, which must be read and registered at each observation of the Barometer. It is preferable in practice to read off this Thermometer *first,* to avoid the error arising from breathing on, or standing long near it, while reading the Barometer itself. The zero of this Thermometer should be ascertained by comparison with a standard at the temperature of about 60° Fahr.

The third correction applicable to barometric observations arises from change of level of the mercurial surface in the cistern, owing to the transfer of a portion of its contents to or from the tube. In Barometers with small cisterns, and where the lower level cannot be adjusted at each observation, its amount may be large, and its effect being always to make the apparent fluctuation less than the real, *in a fixed proportion,* it ought, if possible, to be ascertained. The data necessary to be known are—first, the internal and external diameters of the tube—secondly, that of the cistern containing the mercury, at the surface, where the tube plunges into it. These particulars, as they must be known to the maker, ought to be inquired of

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him, and indeed ought to be engraved conspicuously on some part of the instrument.

Although all these corrections are necessary for the strict *reduction* of registered observations, they ought not to be applied to individual observations previous to registry. It is sufficient to know them. Their effect is in most cases easily and safely applicable to mean results, and to the conclusions therefrom deduced, and a world of troublesome and often mistaken calculations may be saved by so applying them.

Of the External Thermometer.

The External Thermometer should have a scale on which whole degrees are read off, and divisions large enough to admit of estimating tenths, or at least quarters of degrees, by the eye. It should be compared with a standard, and the difference stated, at one or more temperatures (the wider asunder the better) within the range of the climate in which it is to be used. In fixing it, choose a perfectly shaded but otherwise free exposure, and one where no *reflected* sunbeams from water, buildings, rocks, or dry soil, can reach it: and easily accessible for reading. There fix it firmly and upright. In reading it, avoid touching, breathing on, or in any way warming it, by near approach of the person. The quicker the reading is done the better.

Although read off at stated times, notice should be taken of all sudden and remarkable changes of temperature, as indicated by the external thermometer, whenever they occur.

Of the Maximum and Minimum, or Self-registering Thermometer.

This should be placed horizontally in some place out of doors, shaded from direct radiation and rain, and otherwise freely exposed to air, and so fastened as to allow of one end being detached from the fastening and lifted up, so as to let the indexes within the boxes slide down to the ends of the

fluid columns, a more convenient mode, when the steel index is free enough to allow it, than the use of a magnet.

Both the thermometers should be read off as early as possible every morning, and the indexes re-adjusted. But as double maxima frequently, and occasionally double minima occur, in consequence of sudden changes of temperature, it is recommended occasionally to inspect both of them, with a view to ascertain whether the motion either of the mercury or spirit has been reversed in an unusual manner, and such double maxima or minima, when remarkable, should be recorded as 'supernumerary,' with their dates and leading features.

The Self-registering Thermometer is extremely apt to get out of order, by the indexes becoming entangled in the column of fluid. In travelling they should not for a moment be carried with the mercury bulb downwards—if this should happen, they are *sure* to arrive in a state unfit for use. To correct them is tedious, and always hazards fracture. With great care however it may be done, as follows :—

1st. The Spirit Thermometer. By many jerks force the index down to the junctions of the bulb and tube ; then by cautiously heating and cooling alternately the bulb, the tube, or the air vessel at the top, as the case may require, the disunited parts of the spirit may be *distilled* from place to place, till the whole is collected in one column in union with the spirit in the bulb.

2d. The Mercurial Thermometer. When the steel index gets immersed in the mercury it cannot be moved by a magnet, and lets the mercury pass by its side' First cool the bulb (by evaporation of ether, if necessary) till the mercury is ether fairly drawn below the index, or a separation takes place in the column, leaving the index with mercury above it. Endeavour then by tapping, warming the tube, or by the magnet, to loosen the index ever so little, then apply heat to the bulb and drive up the index with its superabundant mercury quite into the air vessel. This requires many trials and much patience. When there, hold the instrument bulb downwards, and suspend

the index by a magnet at the top, allowing any globule of mercury to drop into the origin of the tube below, then heat the bulb cautiously over a very small clear flame of an oil lamp till the mercury rises to the very top of the tube and fairly unites with the globule there awaiting it. Let the bulb cool and the mercury will sink in one united column; if not, heat it again. When this is accomplishe,d the index may be set loose, by withdrawing the magnet, and restored to its proper position in the tube.

A Self- registering Thermometer may be advantageously left (properly secured) for a whole year, or parts of a year, on elevated summits or other remarkable points, to ascertain their maxima and minima of temperature during absence. In such cases, take care to defend them from discovery, or accident from wild animals, birds, snakes, &c. In taking it up for reading off, observe not to derange the indexes, and do not leave it without seeing that the indexes are in contact, and the temperature that of the air at the moment.

Of Thermometers buried in the Earth.

Thermometers buried at different depths, for the purpose of examining the monthly changes of temperature of the soil, should have their balls and lower part of the scale well wrapped up in woollen cloth or pounded charcoal, and should be placed in strong earthen vessels, which may be entirely withdrawn from the ground so as to allow of inspecting and reading off the scale, without, exposing the balls to any possibility of changing their temperatures whi e under examination. The vessels should be fitted with covers, to defend the scale from injury in burying and digging up.

A pipe of earthenware, (composed of separate pieces) or one of wood, may be sunk 10 or 15 feet below surface, into dry earth and a thermometer defended as above, lowered *by a chain.* The pipe being then obstructed at every two feet, by some stuffing readily hooked up, the thermometer may be easily examined, and a register of its indications kept with very little

trouble. In like manner the temperature of wells may be registered.

Of the Temperature of the Sea.

The surface temperature of the water at sea should be registered as a matter of course, with the same regularity and at the same hours as the barometer and thermometer. It is more conveniently (and with quite accuracy enough for the purpose) obtained by taking up a bucket full of the water and stirring round the thermometer in it. Whenever a change to the extent of 2° Fahr. appears to have taken place since the last observation, a fresh bucket full should be taken up and the observation repeated. It should also be noticed whether rain has fallen since the last observation. A sudden depression of 3 or 4° indicates the near approach of land. In a voyage from England, lately made, the temperature of the surface water fell at once 9° Fahr. on approaching within a few miles of the entrance of Table Bay.

The temperature of the sea at considerable depths, can hardly be regarded as a subject of ordinary meteorological inquiry and regular registry, though undoubtedly one of much physical interest, for which reason it is not considered necessary to dwell further on it.

Of the Hygrometer, &c.

In the absence of Daniell's Hygrometer, or of ether to cool it, the degree of dryness of the air may be ascertained by observing the temperatures marked by two thermometers, suspended freely side by side (but not in contact) in the shade, and completely defended from all radiation *to* or *from* the *sky*, the one having its bulb and stem naked, the other with the bulb and lower part of the stem wrapped in linen or cotton, and thoroughly wetted with pure spring or rain water. The temperatures indicated by both, should be noted when the wetted thermometer refuse to sink lower, and the conclusions left for

subsequent calculations. The naked thermometer may be the 'External Thermometer' itself, in which case a coated thermometer may be kept always suspended near it, completely screened as above mentioned, and wetted some minutes previous to the regular daily readings.

If a hair Hygrometer be used, its points of absolute moisture and dryness should be frequently ascertained, as they are apt to change. The former may be found by keeping it some time in a close covered jar lined with wet blotting paper, and having water in it and noting the point of moisture beyond which it refuses to go. The latter, by keeping it in the same manner in a jar perfectly air-tight, over fresh burnt quick-lime, till it refuses to indicate a higher degree of dryness.

The best measure of the *momentary evaporating power* of the air, seems to be the depression of the wetted thermometer below the dry one. But the *actual evaporation* from a given surface, is quite another thing, and a question may very reasonably be raised, how far any useful approximation to a knowledge of the total evaporation from an extensive and diversified surface, unequally moistened, and variously exposed to the sun, defended by clouds, or refreshed by dews, *can* be obtained by any small or local experiments.

The quantity of rain falling in a given time, is a point of some interest.

The rain should be collected through a funnel, in any convenient vessel of regular figure; then the number of inches collected will bear the same relation to the quantity fallen as the area of the funnel to the area of the receiver. Thus, if the funnel be circular, and six inches in diameter, and the receiver be a circular tube of 3 inches diameter, one inch of rain will be measured by 4 inches of the tube. The ratio of the area of the tube to that of the funnel being as the squares of the diameter, or as 1 to 4.

The instrument should be placed in an open space, and in stating the quantity of rain daily received in the guage, the height of the receiver above the soil should be mentioned, experience having shown that the quantities of rain

which actually fall on a given area on the ground, and at a very moderate height above it, often differ materially. In some localities and circumstances, the rain-drops receive accession from the air as they descend, in others they undergo partial evaporation. The former is generally the case in cool moist climates —the latter may be expected in this country.

To measure the temperature of falling rain, it is necessary that the quantity experimented on, bear a considerable relation to the vessel in which it is received. For such a purpose, the rain may be collected in a narrow glass containing a thermometer, by means of a funnel of linen or cloth.

It must be remembered that the guage will often need examination and cleansing, owing to long intervals of disuse in which insects and dust may lodge. It will often happen, too, that the slight rain of one day, if left unregistered, will be entirely lost by evaporation in the next—nay, that slight and transient showers may never enter it, being evaporated from it as they fall. The effect of copious dew, too, must be separated from that of rain, so that the mere registry of the contents of the guage is not of itself a sufficient indication whether rain has fallen in the night or no. However, there are usually good reasons for decision on this point from other indications. Attention to the amount of dew is very necessary, not only because the meteorological questions involved are of a high degree of interest generally, but because in arid climates the dews are of almost as much importance to the maintenance of vegetation as the rain.

Of the Wind.

The points most important to remark respecting the wind, are,

1st. Its average intensity and general direction during the several portions of the day devoted to observation and registry.

2ndly. The hours of the day or night when it commences to blow from calm, or subsides into one from a breeze.

3rdly. The hours at which any remarkable changes of its direction take place.

4thly. The course which it takes in veering, and the quarter in which it ultimately settles.

5thly. The usual course of *periodical winds*, or such as remarkably prevail during certain seasons, with the law of their diurnal progress both as to direction and intensity—at what hours and by what degrees they commence, attain their maximum, and subside, and through what point of the compass they run in so doing.

6thly. The existence of Crossing Currents at different heights in the atmosphere, as indicated by the course of the clouds in different strata. In observing these it is advisable to fix the eye by some immoveable object, as some point of a tree or building, the sun, or the moon, otherwise mistakes are apt to arise.

7thly. The times of setting-in of remarkably hot, or cold winds,—the quarters from which they come, and their courses, as connected with the progressive changes in their temperature.

8thly. The connexion of rainy, cloudy, or fair weather, with the quarter from which the wind blows or has blown, for some time previous.

9thly. The usual character of the winds as to moisture or dryness, not as deduced from mere opinion or vague estimation, but from actual observation of the hygrometric state of the atmosphere during their prevalence.

Among these particulars it will be seen that some are of a nature susceptible of daily observation and registry, while others call for an exercise of the combining and inductive faculty on the observer's part, and cannot be made out otherwise than by continued attention and habitual notice of phænomena with a view to the investigation of their laws. The general impression left upon the mind as to any of the points of this kind above enumerated, by the occurrence of the past month, will therefore be more properly stated, in the way of summary remarks at the end of the Monthly Registers, than as entries under particular days.

The following figures have been suggested to denote the Force of the Wind:—

0. Calm.
1. Light air, just perceptible.

2. Light breeze	in which a ship clean full in smooth water would go	1 to 2 knots.
3. Gentle breeze		2 „ 4 „
4. Moderate breeze		5 „ 6 „

5. Fresh breeze	Or she could just carry on a wind,	Royals, &c.
6. Stormy breeze		Single reefed topsails and top gallant sails.
7. Moderate gale		Double reefed, &c. &c.
8. Fresh gale		Treble reefed and courses.
9. Stormy gale		Close reefed, &c.
10. Whole gale		Close reefed maintopsail and reefed foresail.

11. Storm. Storm staysails.
12. Hurricane. No canvas can stand.

Of the State of the Sky.

In describing the state of the sky as to clouds, &c. the observer will bear in mind that it is only in that region of the sky which is vertically above him that the true forms and outlines of the cloud are exhibited, and the area they cover, as well as the intervals between them distinctly seen. As they approach the horizon in any direction, their extent is foreshortened by perspective, their apparent magnitude diminished by distance, and their intervals covered in and hidden by their mutual interposition. In estimating therefore the quantity of clouds in the sky, regard must be had to this, and our judgment should rather be formed on a view of the region extending from the zenith every way half way down to the horizon, than from the aspect of the heavens below that limit. It would be better to notice both, and state, separately, the proportions in which each are covered, and the quarter of the horizon towards which the chief masses in the lower region lie.

The general aspect of Clouds should be noticed, and especially the height of their inferior surfaces, or the level of the *vapour plane*, should be estimated. In a mountainous region this is easy so long as the vapour plane is below or not far above the summits of the hills, and in such regions the formation and dissipation of cloud in the neighbourhood of the mountain summits, under the influence of certain winds, form a subject of study of a highly curious and interesting nature.

The formation of Clouds at night, during calm weather, under the influence of a gradually descending temperature, is another point worthy of attention. It frequently happens, that, without any perceptible wind, the sky will suddenly become hazy in some one point, and the haze condensing and spreading, in all directions, without a wind, the whole heaven will become overcast in a remarkably short time. The same thing will sometimes occur nearly at the same hour for many nights in succession. Such phænomena should be noted whenever they occur.

The following abbreviations have been suggested to denote the state of the weather :—

b. Blue sky, whether atmosphere is clear or hazy.
c. Clouds, detached passing clouds.
d. Drizzling rain.
f. Foggy.
g. Gloomy dark weather.
h. Hail.
l. Lightning.
m. Misty hazy atmosphere.
o. Overcast, or whole sky covered with thick clouds.
p. Passing temporary showers.
q. Squally.
r. Rain, continued rain.
s. Snow.
t. Thunder.
u. Ugly threatening appearance.
v. Visible clear atmosphere.
w. Wet dew.

Example.

gv. Gloomy dark weather, distant objects remarkably visible.

° Under any letter, denotes a great degree.

It is desirable to use Mr. Luke Howard's nomenclature of clouds, which is generally adopted.

There are three simple and distinct modifications which are thus named and defined:—

1. *The Cirrus.*—A cloud resembling a lock of hair or a feather. Parallel flexuous or diverging fibres, unlimited in the direction of their increase.

2. *The Cumulus.*—A cloud which increases from above in dense, convex, or conical heaps.

3. *The Stratus.*—An extended, continuous, level sheet of cloud, increasing from beneath.

There are two modifications, which appear to be of an intermediate nature these are:—

4. *The Cirro-cumulus.*—A connected system of small roundish clouds, placed in close order or contact.

5. *The Cirro-stratus.*—A horizontal or slightly inclined sheet, attenuated at its circumference, concave downward or undulated. Groups or patches having these characters.

Lastly, there are two modifications, having a compound structure, viz.

6. *Cumulo-stratus.*—A cloud in which the structure of the cumulus is mixed with that of the cirro-stratus or cirro-cumulus. The cumulus flattened at top, and overhanging its base.

7. *The Nimbus.*—A dense cloud, spreading out into a crown of cirrus, and passing beneath into a shower.

Of Thunder and Lightning, and of the Electrical state of the Air.

Connected with this part of the subject is the observation of shooting Stars and luminous Meteors. Remarkable ones should be noticed, and the moment of their appearance, their direction, duration, length of path, and *course among the Stars,* as-

certained and noted, with the phænomena of their increase and decay of light, apparent size, separation into parts, trains left behind, &c. The *general* direction (if any) which they observe on particular nights, is a point also to be attended to.

It is recommended to keep a look-out from the 10th to the 15th November for falling stars. About this period they have appeared in great numbers, according to the testimony of many observers. The observer should make himself acquainted with the principal stars, so as to be able to trace the course of these meteors.

Thunder storms of course will be noticed when they occur under the general head of the weather, but it is of consequence also to notice distant lightning, not accompanied with thunder audible at the place of observation (by reason of its great distance),* especially if it takes place many days in succession, and to note the quarter of the horizon where it appears, and the extent it embraces. In an actual thunder-storm, especial notice should be taken of the quantity of rain that falls, and of the fits or intermittences of its fall, as corresponding, or not, to great bursts of lightning, as also of the direction of the wind and the apparent progress of the storm with or against it.

Observations of the Electrical state of the Air in serene weather are unfortunately too much neglected. The apparatus they require is simple, and by no means costly, and may be constructed indeed by any one for himself with ease.

There are various other points of great interest which can only be glanced at. Is the earth arrived at a permanent state as to temperature? This may be resolved by observing the mean temperature at sea, at a great distance from land. A very long series of observations near the equator will not be necessary to determine this with some degree of precision.

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* Thunder can scarcely ever be heard more than 20 or 30 miles from the flash which produces it. Lightning on the other hand may be seen (or at least its reflexion on the Clouds, forming what is called *sheet lightning*) at the distance of 150 or 200 miles

It has been stated that the solar rays heat more in *high* than in *low* latitudes.

Experiments may be made to determine these points by employing two thermometers—one with a black bulb, the other white.* These should be exposed to the sun's rays when at equal altitudes and the respective heights of the mercury marked. A calm day should be chosen for this purpose.

It has been stated, that in the equinoctial regions, the temperature a foot below the surface of the earth is nearly the mean temperature of the place. A covered spot should be selected, and the hole in which the thermometer is placed, should be covered, so as to exclude the air—on taking up the thermometer, read off quickly. The temperature of wells of middling depth, gives also the mean temperature of the surface.

It has been supposed that halos are caused by rays refracted from ice. According to this theory, the horizontal and vertical diameter should be equal. Reflecting instruments offer an easy mode for making these measures, which should be always done when the halos appear elliptical to the eye.

The interior edge is the best defined. Care should be taken to note with which limb of the sun or moon it is compared.

MAGNETISM.

Magnetical observations are of great value, but few possess the necessary instruments. The generality of observers must therefore confine themselves to the declination of the magnetic needle (variation of the compass.)

The instrument should be used on shore, and great care be taken that the sights are perpendicular to the face of the instrument. The usual instrument supplied to ships is rude, therefore observations must be multiplied to get rid of its errors. The sights should be shifted round to the various positions and

* A covering of black and white silk is recommended for this purpose.

the observation be repeated to eliminate errors of centering and division, and sights be taken morning and evening. If more than one card be supplied, use it, noting the respective marks.

If the observer has a prismatic compass, the true bearing of a distant object in the horizon, may be determined from the distance of the sun's limb observed with a sextant, and repeated bearings of it be taken with the compass. As many points as offer may be used for this purpose.

It cannot be expected that very delicate and precise observations can be made by persons unprovided with the requisite instruments, or not previously trained to their use. But many important observations may be made, if care be taken to conduct them with accuracy, and to note down the concommitant circumstances. The existence or non-existence of a second northern magnetic pole, has yet to be determined, and observations made in the China Seas would throw great light on this point. The magnetic declination, inclination and intensity may all be observed on board of ship with sufficient accuracy to afford valuable results, and when opportunity offers, the experiments may be repeated on shore. The following precautions are to be observed :—

1st.—Every series of observations on board should be accompanied by a notice of the direction by compass of the ship's head at the time.

2d.—Previous to sailing, a careful series of the apparent deviations, as shewn by two compasses, permanently fixed, the one in the binnacle and the other considerably further forward, in every position of the ship's head, as compared with the true position of the ship, should be made and recorded, and these observations should be repeated during the voyage when opportunity offers of swinging the ship's head round to the four cardinal points, and executing in each position a complete series.

3d.—When observations are made on land, they should be carefully compared with others made on board, in order to obtain accurately the corrections due to the ship's action.

4.—All changes made in the disposition of ballast or other large masses of iron, between different series of observations, should be noted.

No opportunity should be lost of making magnetic observations on shore, the latitudes and longitudes of such stations should be accurately determined. The state of the barometer and thermometer should also be recorded.

BOTANY.

Collections of plants may be made in the usual way, by drying, taking care to preserve as much of the stalk and leaves as possible ; besides the flower and seed vessels. Those who are not botanists, may limit themselves to collecting plants which they find used by the inhabitants of the places they visit, for economical purposes. The seeds of useful plants should be collected and carefully preserved from damp, which is best done by packing them in brown paper; and hanging them up in a cabin, or any part of the ship. The nature of soil and climate of plants, which may be useful in other countries, should be noted, that they may be sent to places where they are most likely to succeed.

Directions for Collecting and Preserving Plants in Foreign Countries for a Herbarium.

This is a much simpler process than is generally imagined by those unpractised in it, and travellers have been often deterred from collecting specimens by the time and trouble required for preparing them in the way that has by many been recommended.

The chief circumstances to be attended to are, to preserve specimens of plants in such a manner, that the moisture may be quickly absorbed, the colours, as much as possible, preserved, and such a degree of pressure given to them as that they may not curl up in the act of drying.

For this purpose, let a quantity of separate sheets of paper be obtained of a folio size. Common brown paper is upon

the whole the best, except for the very delicate kinds, which require paper of a smoother and more absorbent texture. Blotting paper, however, especially in warmer climates, would absorb the moisture too rapidly, and by repeated damping and drying would soon be rendered useless.

Two boards should be provided—one for the top, the other for the bottom of the mass of papers.

For pressure at home or when stationary for any length of time in a given spot, nothing serves better than a weight of any kind (a folio book or a large stone, &c.) put upon the topmost board: and the great advantage of this is, that the weight follows the shrinking of the plants beneath.

Whilst travelling, three leathern straps with buckles should be procured; two to bind the boards traversely, and one longitudinally. It will be further desirable to have a number of pieces of pasteboard of the same size as the paper, to separate different portions of the collection either such as are in different states of dryness, or such as by their hard woody nature might otherwise press upon, and injure the more delicate kinds.

Thus provided, gather your specimens, if the plants be small, root and stem, if large cut off branches of a foot, or a foot and a half in length: selecting always such as are in flower, and others in a more or less advanced state of fruit.

Place them side by side, but never one upon another on the same sheet, and lay upon them one, two, or three sheets, according to the thickness of the plants, or their more or less succulent nature: and so on, layer above layer of paper and specimens, subjecting them then to pressure.

As soon as you find that the paper has absorbed a considerable portion of the moisture (which will be according to the more or less succulent nature of the plants, and the heat or dryness of the season or climate) remove the plants into fresh papers, and let the old papers be dried for use again,—either in the open air, or sun, or in a heated room, or before the fire.

As to the spreading out of the leaves and flowers with small weights, penny pieces &c. it is quite needless. The leaves and flowers are best displayed by nature in the state in which

you gather them, and they will require little or no assistance with the hand, when laid out upon papers, to appear to the best advantage, especially if put in carefully on being fresh gathered.

If the specimens cannot be laid down immediately on being gathered, they should be preserved in a tin box, or failing that, in a rush basket, where they will keep fresh for a day or two, if the atmosphere be not very much heated.

Some very succulent plants, such as Cacti, Semperviva, Seda, Orchideous plants which grow on trees, &c. require to have the specimens plunged into boiling water for a few seconds, before they are pressed, to destroy life, and thus accelerate the process of drying.

Plants with very fine but rigid leaves, as the Fir tribes and the Heaths, and some with compound winged leaves, to prevent their leaves falling off, or their parts separating, may either be treated in the same manner, or dried in very hot paper, or with a hot iron.

In many cases, especially in warmer climates, the traveller will find the process accelerated by exposing the parcel (hung up and properly secured) to the open air, when the weather is favourable, and the circulation of the air through it will be promoted if the sheets on which the specimens are laid be placed alternately back and edge. In tropical countries he will find it necessary to shift his specimens at least once a day, and by changing them into hot paper, and crowding such specimens as are dry, he will be enabled to form a considerable collection in a small compass, and in a very short time. Four or five shiftings will generally be sufficient to complete the process, which is ascertained by the stiffness of the stems and leaves, and by the specimens not shrinking when removed. They should there be placed between dry papers, and formed into parcels of moderate thickness, and either packed in boxes; or well secured as parcels covered with oil cloth.

Palms having their fructification and leaves very large, can hardly be subjected to pressure: a few flowers should be pressed, and the whole cluster of flowers and fruit, as well as leaf,

may be simply dried in the air, and afterwards packed in boxes for transportation.

The greater number of Cryptogamic plants may be dried in the common way, such mosses as grow in tufts being separated by the hand. But both mosses and lichens, as they can at any future time be expanded by damping, may be dried by the traveller without pressure, and put up, either each species separately, or several together, in small canvas or paper bags, carefully marking the place of growth, and the date when gathered.

If the fruits of plants are of small size so as to be preserved in a herbarium, they should be gathered with the leaves and branches, as are the flowers, if of a large size.

Dry fruits demand no care, except that those which split into valves should be tied round with a little packthread.

Pulpy fruits are only to be preserved in spirits, or in pyroligneous acid diluted in the proportion of eight parts of water to one of the concentrated acid. In all cases the separate fruits, whether dry or preserved in a fluid, should have a number attached to them, referring to the flowering specimens of the plants.

Seeds, whether for examination, or intended to be sown, should be gathered perfectly ripe, put up in brown paper bags, and kept dry in a box.

With the specimens, fruits and seeds, there should be slips of paper, on which are to be written the uses, native names, and general appearance of the plant, whether herbacous, a shrub, or a tree; its sensible qualities, and the colour and form of the flowers; its situation, if dry or damp; the nature of the soil; the elevation above sea level, and the date when gathered.

As soon as a sufficient number of specimens are collected, no time should be lost in transporting them to their place of destination, since in warm climates especially, they are liable to the attacks of insects. These attacks, which are often completely destructive of the specimens, may in many cases be prevented by pitching the boxes, and by putting in them, or

in each parcel, cotton dipped in petroleum, spirits of turpentine or small pieces of camphor, and the captain of the vessel should be particularly requested to keep them in a dry and airy part of the ship.

Specimens of the woods from six to eight inches in length, the entire round of the trunk or branch of small, and segments from centre to circumference of the larger kinds, in both cases with the bark, should be preserved—not only of the more remarkable trees but also of the woody climbers which often exhibit peculiarities of structure highly interesting to the botanist. When specimens of woods are preserved, they should be marked with numbers corresponding with the flowering branches of the tree in the collection of specimens; and when flowers cannot be obtained, a small branch, with leaves or fruit, should always be taken.

Gums, resins, and other remarkable products should also be collected; their uses, if known noted, and reference made by numbers to the plants they belong to.

Useful and ornamental plants would of course form the most important parts of such collections; but even the weeds of foreign and little known countries, the grasses, ferns, mosses, lichens, and sea weeds will prove extremely valuable to the scientific botanist.

Hints relative to the Care and Preservation of Plants and Seeds intended to be forwarded from China to India and England.

The usual mode of sending living plants in open boxes to distant parts of the world by sea, has been found very defective, and often unsuccessful; unless very great attention has been paid to the care of the plants during the voyage. Of late years a far better and easier method has been adopted; it consists in putting the plants in boxes which admit of being closed for good at the time of embarkation, not to be again opened until they arrive at their destination. The great drawback on the old method was this, that the plants were neces-

sarily to be watered almost daily during the passage, and minute attention was likewise required to open and shut the lights or lids according to circumstances. The permanently shut boxes require, indeed admit of no watering at all; nothing further being wanted, than to place the boxes securely on the poop, or on the quarter deck, where there is no poop, fully exposed to the rays of the sun. The process in regard to these closed boxes being simply to put the plants in a box with glazed, slanting lids, in a light soil composed of loam and vegetable mould; to cover the soil with a couple of inches of fresh moss where it can be had; to give the plants a good watering, so as to moisten the earth thoroughly; and then to close the lids down by means of screws as tightly as possible. The rays of the sun put the moisture within the box into circulation, ascending in vapour during the day time, and falling down again after sunset in the shape of a refreshing dew. The construction of the box ought to be such as not allow the damp air either to escape, or to enter from without. The stouter the planks are, of which the box is made, the better; the fastenings should be made very tight; there should of course be no holes at the bottom, nor any at the ends (for ropes to hoist the box up or lower it down). The accompanying diagram (altered from a very able paper of Dr. Lindley's on the subject of open boxes) will better explain the form of the boxes than a mere description. In general, they are made three feet in length by two feet nine inches in height, and two feet in width. The bottom or square part is about fourteen inches deep, and the lights measured along the slopes, very nearly two feet. The end view* in the accompanying paper shows the angle at which the two lights or lids should converge, it having been found the most advantageous in practice. It is necessary to use glass, or at any rate talc for the panes; in the former case, these ought not to exceed six inches in length, by about one half in breadth; each lid contains twenty-four of these little panes, but of course

* See Diagram at the end of the pamphlet.

the number may vary according to circumstances. The bars in the lids are two and a quarter inches wide; they are quite flat, and present with the panes an even surface, so that rain falling upon them runs off without difficulty, while the maximum of day light is freely admitted:—a point on which the principle of these hermetical boxes essentially hinges. It is a very material point to fix the panes as firmly and air-tight as possible by means of good putty. For security's sake, three slender pieces of wood are fixed across the lids on the outside, one over each horizontal row of panes; these form an additional protection against accidental breakage from the falling of any thing upon the boxes, &c.; and the width of the bars admit of a thin piece of board being readily fixed upon any of the squares of which the pane might happen to break; and this must be done the moment the accident has happened. Wherever a strong copper, or iron-wire grating can be obtained, it will of course be an excellent outer protection to the lights. The oyster-shell panes commonly employed in China in the construction of open boxes, would be useless for the purpose.

The depth of the earth in the bottom of the box should not exceed six inches, and the plants should not be crowded too much, say about twenty-four in a box of the size mentioned. It is very important to attend to the following two points: first, wherever this can be done, to select such plants for putting into the box, as are quite strong and healthy, and rather robust in stem; and above all, to take great care not to injure the roots in taking the plants up, or in planting them. Superfluous branches, or such as are much in the way of shutting the the lids, may with safety be cut off. As mentioned already a good layer of fresh moss is very useful as a covering to the soil in the boxes; it serves as a sort of living fountain. As soon as the box is filled, it may be closed for embarkation; care being taken, that the plants are well watered first. But wherever it can be done, it is desirable to allow the boxes to remain open for some time, and the longer the better, in

order that the plants may become strengthened and habituated, as it were, to their new locality, before their prison is finally closed.

The boxes ought to be provided with legs (one at each corner) so as to lift them up sufficiently from the deck. Four inches is the usual height of these legs in the dimension of boxes described.

Roots of a fleshy nature such as those of the ginger and turmeric tribe, bulbs, as well as tubers may be put into shallow boxes, in alternate layers of dry sand, or still better in moss. They should be put in the open air for a day or so, after they have been taken up and cleansed from the soil, previous to being packed up. China possesses no doubt a great variety of plants of the above classes, which would be great acquisitions both here and in England. There is likewise a great variety of the kind of plants commonly called parasitical or air-plants (orchideous,) growing upon rocks and trees. These are comparatively of easy management, by detaching them cautiously so as to injure the fleshy roots as little as possible, and placing the entire plants in moderate sized strong baskets either by themselves, or lightly covered and surrounded with moss. Wherever it can be done, the best plan is to cut off the branch on which the air-plant grows, and placing it bodily in the basket. These baskets may be hung up in a cabin, or between decks, occasionally opening them during the voyage, to give the contents a little airing; this last may also be adopted in regard to the boxes of roots and bulbs.*

The best way of preserving seeds is to let them remain in their natural covering—that is, in their own husk or seed-vessel. This rule holds particularly with all sorts of dry fruits, capsules, pods and the like. The seeds of fleshy fruits may be taken out and dried in the shade. Common brown cartridge paper has been found to answer best for envelopes; and experience has shown, that papers of this sort, or even

* Some of the air-plants may likewise be attached to the sides of the closed boxes.

loose seeds or seed-vessels that were allowed to tumble about in drawers or the like on board the ship during the passage, have arrived, at their ultimate destination, in a fresh and sound state, fit for immediate sowing; while others, packed and attended to with the utmost care had lost the last spark of life notwithstanding their outward promising appearance of freshness. It is needless to say that, under all circumstances, the hold and all similarly confined places on board the ship would, in a very short time, destroy the life of seeds as well as roots of any description whatever. Seeds of an oily or fleshy nature, such as lose their vegetative power, soon after they ripen; for an instance, acorns and chestnuts, of which it is presumed that there are many sorts in China, had best be sown in the boxes among the plants, so as to allow them to spring up during the voyage, or they may be put in layers of dried earth, or sand, in a shallow box; but the former mode is by far the safest.

The Chinese empire is beyond all question abundantly supplied with the most interesting and valuable vegetable productions, yielding to no country on earth in that respect. The nation is notoriously fond of horticulture in all its branches, and under ordinary circumstances much aid might be expected from the native gardeners in all large sea ports. Very few Chinese plants, comparatively speaking, have found their way either to India or to England; and any object which may appear new or curious, should be at once considered in the light of a desideratum to be sent to India or to England. Here will be acceptable whatever is sent, for although the climate of lower Bengal may not generally suit the plants of China, yet there is the obvious alternative of sending them up to the higher and temperate parts of India. Air-plants of all descriptions thrive well here, and they are most particularly an object of great desire in England. All plants that are useful as articles of food, medicines, dyes &c., should be attended to, each individual of which would be very welcome.

ZOOLOGY.

In making zoological collections, it is necessary to observe that the animals be as little injured as possible in catching, otherwise the specimens will be imperfect. Snakes, lizards and reptiles should be immersed in spirits as soon as possible. Shell fish, snails, sea anemonies, &c. should be allowed to die in the water to which they are accustomed,and then immediately immersed in spirits, to prevent putrifaction. To each specimen should be attached a number stamped on sheet tin, corresponding to a catalogue in which should be entered the place and time of obtaining, the kind of locomotion and other vital phenomena, and the colour of the living animal. Animals, small enough to be preserved whole, should be kept in that state. Such as are too large to be brought home whole should be divided into those parts which characterize them.

Mammalia.—The smaller mammalia may either be skinned or inclosed entire, (an incision being previously made in the under side of the animal) in jars or barrels, which are to be filled up with some spirituous liquor, as gin, or what is preferable when it can be procured, proof spirit diluted with half its bulk of water. If no spirit can be had, strong brine must be adopted. In respect to their retaining their natural colour, brine is even preferable to spirituous liquors, for preserving the specimens.

When any new of this kind are taken, so as to be thought worth preserving, it is necessary to notice the external appearance, the number of nipples in the female, and their situation, whether between the anterior extremities, as in the human subject, monkey, and elephant, &c., or all along the belly, as in the sow, rat, bitch, &c., or between the hind legs, as in the mare, cow, &c. If the female cannot be procured, the male should be observed—it sometimes happens that the male, as the horse for instance, has no such parts. The situation and appearance of the male organ must also be noted and described,

whether along the belly as in the dog, pointing backwards as in the cat, covered by the skin as in the bull, deer, &c., or attached by a proper skin as in the dog, horse, &c. Any other external part, which cannot be preserved, should be accurately noticed.

The external parts are then to be examined and noted, as, the number of lobes in the liver—whether there be a gall bladder—what kind of kidneys, &c. Animals whose food is not known should have the contents of the stomach examined.

To skin the larger mammalia, make an incision in a straight line along the belly from the vent to the throat, and detach the skin carefully with the knife.*

The skull and bones of the legs and feet are to be left. The brain, eyes and tongue must be extracted, and as little fat as possible be suffered to remain adhering to the inside of the skin, which is then to be dressed with the arsenical soap, for the mode of making and applying which, see a subsequent page. If, however, some fat remain, which cannot well be got rid of, strew it with powdered tan (or the bark of oak, willow &c.) previously to applying the soap. Mr. Wiltshire has given the following as the method of dressing skins used in Morocco :—

Wash the skin in fresh water, scrub off the flesh and dress the inside with some of the following mixture :—alum, two pounds ; buttermilk one quart ; meal two or three handsful, fold it up carefully and press it together. After two days wash the skin, drain off the water, dress it well on the inside with powdered alum and fold it up as before. After three days unfold and dry it in the sun, without removing the alum ; when dry sprinkle it with fresh water, again fold it for two hours, and then scrape the inside clean, and rub it with sandstone until it becomes soft and pliable ; then hang it in the shade to dry.

The head of a quadruped should be saved, and the teeth carefully preserved. The feet and tail should be kept attach-

* Make all incisions where they will be least visible when the skin is set up as the insides of the legs and thighs ; but practice will be the best instructor in this purely mechanical business.

ed to the skin and dried, and if the skin be not preserved, they may either be dried, or put into spirit.

The stomach, if preserved, should be put in spirit, with a part of the duodenum.

The contents of the pelvis, viz. the bladder and rectum, with the internal parts of generation both male and female; also the external parts not separated from the internal, with a portion of the surrounding skin, may be preserved in spirit. If the female parts are in a state of impregnation they are to be taken out without opening the uterus.

The ears, lips and feet of large mammalia should when practicable be well anointed with spirits of turpentine which will assist their drying and tend to destroy insects; when dry roll up the skin with the hair innermost, beginning with the head, and put a layer of dried grass or moss between the folds to prevent its being injured by rubbing. The skin must be occasionally unrolled, and examined, and if practicable exposed to a hot sun, and fresh spirits of turpentine added if any symptoms of insects should appear. Tobacco, the stronger the better, strewed in the package will be serviceable and in countries where spices and aromatic drugs can be procured at a reasonable rate these may be used to great advantage, and even supersede the necessity of applying the arsenical soap.

When a very large animal has been killed, under circumstances which prevent the application of the arsenical soap, the skin should be stretched out on the branches of a tree, to give the air free access to every part of it, and as soon as it is cold, well dressed on the inside with wood ashes.

Entire skeletons (especially of the rarer animals) should be procured when possible. It is not necessary that they should be jointed or set up, but, having removed all the soft parts, boil the bones, and when they are well dried, pack them with moss or grass or the best packing stuff at hand, so that they may travel securely. Take especial care that not a bone, tooth, or claw, be lost.

The bones of animals to be preserved, should, if possible, be full grown. The bones should either be boiled, or preferably,

be put into a cask with water, or lime water, which should be headed in and bunged up.

Birds.—In respect to birds, the collector should proportion his shot to their size, so as to injure the skin and feathers as little as possible. As soon as the bird falls the blood should be carefully wiped up, and cotton placed within the beak, to absorb any that might flow from the mouth, and thus prevent its staining the plumage.

Birds should be skinned as soon as may be after they are killed, for, if suffered to remain till putrifaction has begun, the feathers fall off. The mode of skinning birds is very similar to that of skinning mammalia, and equal care must be taken, both to make the incisions as small as possible, and in the least visible parts, and the feathers must be separated so as not to be injured by the knife in dividing the skin. The head and legs must, in all cases, be carefully preserved, and the os coccygis let in the skin, otherwise the tail feathers will be liable to drop out. In packing the skins, care must be taken that the plumage be not injured by contact with the harder parts, which, for that purpose, should be surrounded with cotton, tow, or the best soft packing material at hand, as dried leaves, or grass. When more than one individual of the same species can be procured, it is desirable that a second specimen should be preserved in spirits, and the same remark applies to the smaller mammalia, and indeed, to all other orders. The bird skins must be dressed with the same materials as those of the mammalia, but the arsenical soap, if used at all, must not be too liberally applied.

As the plumage of birds varies extremely at different periods of their life, and even at different seasons of the year, it is of great importance to obtain both sexes, if possible, of all ages, from the chick just hatched to the adult in its maturest plumage; and also in their summer and winter liveries. Birds' eggs should also be anxiously sought for, and the species carefully identified. The best method of emptying them is, by making a single hole near the middle of the shell, of about

a quarter of an inch in diameter, into which a small tube is to be inserted, so as nearly to touch the opposite side of the shell, which being held with the hole downwards, is easily emptied of its contents by blowing pretty strongly through the tube. If no more convenient instrument be at hand, a straw will make a very serviceable blow pipe. Birds nest are rather nuisances than otherwise, in collections, from their occasioning dirt and litter, and being frequently infected with insects; nevertheless as part and parcel of ornithology, they possess a high degree of interest, and must by no means be neglected. The collector should therefore take accurate descriptions of the materials, form, and size of every kind of nest he finds, always being extremely cautious to ascertain the species to which each respectively belongs: he should also make careful drawings of every variety, and even collect such of the smaller nests as possess any peculiarity in point of material, structure and mode of suspension.

Reptiles and Fish.—Are best preserved in spirits, each specimen being previously wrapped in a linen cloth; but when too large to be so treated, serpents and fish must be carefully skinned with the least possible injury to the scales, or any of the external organs, and with especial caution not to destroy the form of the skin, which may be preserved by stuffing it lightly with cotton or tow, or filling it with saw dust; and the skin dried with the head, feet, and fins on. Instead of being skinned whole fish may be divided into two nearly equal portions, by an incision passing longitudinally through the vertex of the head, the back, and belly; but on one side of the dorsal, candal, anal, and ventral fins, so as to leave one half of the animal with the gills and all the organs of motion perfect. The flesh may then he easily removed from this portion, and replaced by tow, which will preserve the form of the body; when well dried, this portion is to be carefully packed. On the whole, this method deserves the preference above all others and the fish thus preserved when provided with proper artificial eyes, and mounted on flat boards, afford excellent specimens.

Reptiles, as snakes, lizards, frogs, &c. should be preserved whole in spirit, unless very large; they may then be skinned, and treated with arsenical paste, and dried like other animals. The contents of the thorax, especially the heart and large blood vessels of these animals should be preserved in spirit.

The upper and lower shells of the tortoise tribe should be separated by dividing the ligamentous or bony portion which unites them on each side between the fore and hind legs after which the fleshy parts may easily be removed, the head, legs, and integuments of the body being carefully preserved. As to the lizards and crocodiles, they may be skinned in the usual manner, care being taking not to injure the tails of the former which are very brittle: or when not too large preserved in spirits, which is still better.

The form and colour of the eyes in all the vertebrata, of whatever class, should be carefully observed and noted down the moment they are taken. This precaution should never be neglected.

In collecting shells whether terrestrial or aquatic, the naturalist must always give the preference to live shells, that is, such as are still inhabited by the living animal; but if they cannot be obtained, dead shells are better than none, though for the most part they are worn and faded. The more delicate species must be packed in cotton or other soft substance, or in default of such, in fine saw-dust. Shells containing their animals, as well as all naked mollusca, must be preserved in spirit or brine.

Animals of the firmest kind may generally be preserved in a quantity of proof spirit equal to their own weight. Soft or watery animals require more, but regard must be had to the climate, and in a hot climate more spirit will be required, or if the animal is to remain a long time. If it be a large animal, it ought to have the thorax and abdomen filled with spirit before immersion, otherwise the internal parts will become putrid. When spirits cannot be procured, specimens may be temporarily preserved in a saline solution; consisting of one part by weight of common salt, two parts of alum, and ten parts of water.

Animals preserved for their external form should be suspended, those intended only for dissection may be put into a bottle or cask, without suspension. If two or more are put nto the same vessel, they should be kept separate ; when suspended, more may be put into the same vessel, because they cannot press on one another. Animals which are put into spirit should have it changed about a fortnight after the first immersion ; because the spirit will be lowered by the juices of the animal, and unfit to preserve it—but careful examination is the best guide in this. The corks of bottles should be covered with bladder or skin, and then coated with resin or wax, but the cork itself must not be waxed, or it will be dissolved by the spirit, and adhere to the preparation. All preparations should be so packed as to allow of being occasionally examined and aired.

In collecting shells, the common oyster dredge, used on the coast of England, or a small net of similar construction would be found very valuable. Small shells frequently come up attached to the deep sea lead, from considerable depths; these should be carefully preserved, if they are alive, in spirits. A towing net is also very useful for taking those marine animals that are to be found on the surface. Great care should be taken to preserve shells perfect.

Crustacea.—The marine species may be killed by being immersed in cold fresh water, and they should be left in for several hours to free them from the adhering salt, which if not well washed out, renders them liable to attract moisture from the atmosphere and injure the specimens: when well washed, separate the upper shells and remove as much of the fleshy parts as possible ; and then carefully dry and pack them. The smaller species may be pierced with pins, like insects, if the consequent bulk of the packages be not an objection. Entire crustacea may be preserved in spirits or brine.

Humanity requires that all animals which we collect should be deprived of life in the most expeditious and least painful manner that can be devised, and no agent appears so effectual

as pure hydrocyanic (prussic) acid. A small quantity of that fluid is to be placed in a well corked phial, or other close vessel with a piece of blotting paper to prevent its flowing over the specimens. The vapour of this acid (which the collector must be careful to avoid inhaling) thus fills the vessel, and is so fatal to animal life that almost instant death ensues on placing a subject within its destructive influence. Though chiefly employed for killing insects, prussic acid used as above directed, is equally applicable to every animal not too large to be exposed to its vapour in well closed cases.

Arachnæ.—Spiders, scorpions, and acar are best preserved in spirits as well as myriapoda, including the juli, scolopendræ and other individuals of the order, but no good method sufficiently easy and simple to be practised by the travelling collector, has been hitherto discovered for effectually securing the colour of many of the animals of this class, especially the spiders.

Insects.—The thysanuræ and parasitic insects, the former including the lepismæ, petrobii and poduræ, the latter the pediculi and nirmidæ, are very minute, and may be collected in quills, and killed by exposure to heat or the vapour of prussic acid. The parasitic insects infest mammalia, birds, reptiles, fish and even insects. Birds, especially are subject to these pests, and in some instances certain parasites are peculiar to a particular species. The collector must therefore carefully inspect the plumage of all the birds he kills, and accurately note down from what species each individual is respectively taken. The examination must be made while the bird is still warm, as the parasites leave the body soon after it becomes cold. Lyonnet laid a sheet of paper on the body of the dead bird, and placed on it a well warmed and folded handkerchief: the heat induced the insects to leave the bird, and assemble on the paper, and thus they were easily collected.

Coleoptera.—Beetles may be at once put into spirits. The late unfortunate Drummond packed coleoptera, both large and small, in pill boxes with powdered camphor, placing a disc of tissue paper between each layer of insects. In this way not a

specimen was injured, and the insects retained sufficient moisture not to need being relaxed before they were pierced. Besides prussic acid and spirits, coleoptera may be killed by immersion in nearly boiling water.

The collector must omit no opportunity of obtaining the larvæ and pupæ as well as the perfect insects. They may be preserved in spirits ; or in the following way, invented by M. Laurent: Kill the larvæ with the prussic acid vapour; then pass a pin into the anus, and expel the intestines and their contents by pressing the body between the thumb and forefinger beginning at the head. When well emptied, insert a straw or other small tube proportioned to the size of the larvæ, into the anus, and fix it in its place by means of a small pin, passed through the last segment of the skin of the larvæ and the tube: next expose the skin to a gentle heat over a chafing-dish of coals covered with an iron plate, till it has contracted round the tube, which will take about half a minute; then, by blowing through the tube, the skin will swell out, and resume its original form, in which state it must be carefully dried over the hot plate, turning the tube round and round, and continuing to blow that the skin might not collapse, and the larva retain its perfect form. If the pin and tube adhere to the skin, cut each off as close as possible, without attempting to withdraw them.

Orthoptera.—Including the earwigs, cockroaches, mantes, locusts, and some of the Omoptera, as the lantern fly (Fulgora) and cicada, may also be preserved in spirits—but better dry; in which case, they must be pierced through the thorax, the intestines being carefully removed, and replaced by cotton.

Of the remaining orders, the neuroptera, hymenoptera, lepidoptera, and dipteræ are best preserved by being pierced vertically through the thorax* with a pin, and stuck securely in boxes lined with cork, or some substances sufficiently soft and elastic, to allow the pin to enter it easily and hold it securely. To save space, several insects may with great caution

* Coleoptera are always to be pierced through the right elytrum, so that the pin may come out beneath, between the first and second pair of legs.

be placed on one pin; and those lepidoptera whose wings, when at rest, are carried vertically on the back, may be pierced through the thorax laterally, by which a greater number may be fixed on one pin. The box should be filled with prussic acid vapour as before directed.

The species of these orders, except the lepidoptera, may also be kept in pill boxes, but piercing them is preferable.

The hemiptera should be pierced through the thorax, and the sooner after they are caught the better, as they become very brittle on drying.

Most insects may be dried—great care must be taken to preserve their external parts perfect. They may be killed by thrusting through them a pin dipped in nitric acid; they may then be pinned upon a board, or upon cork. The pins run through them should be oiled or greased, to prevent rust. Corrosive sublimate, or camphor must be used to prevent the attacks of other insects. Moths and butterflies are best preserved between two pieces of glass, cemented together at the edges with lac or sealing wax.

Parasitic insects, which infest fishes and other animals, should be preserved.

Asteriæ (star fish) including the ophiuræ and comatulæ, as well as the whole tribe of worms, amphitrites, nereides, leeches, tæniæ, gordii, together with all the lower animals not provided with shells or solid covering, may be preserved in spirits; or if more convenient, the asteriæ, having been first well soaked in fresh water for several hours, may be extended on boards, with their arms retained in the proper position by pins, till quite dry, and then very carefully packed in tissue paper and cotton.

The echini (sea eggs) are very difficult to preserve dry with their spines on, especially the Indian species, which have very large and heavy spines. Having killed the animal, expand the arms, and clear out the contents of the body as completely as possible, with a small spoon or ear pick; then soak it for ten minutes in fresh water, taking care that the spines do not fall off. Next fill the shell with cotton, and lay it on a board, and

introduce between each spine a little ball of cotton, or silver paper, so as to retain them all in their proper position, and let them dry undisturbed. Then pack each specimen carefully in a separate box, leaving the cotton or paper between the spines. If want of time or stowage room forbid this method, preserve the specimens entire in spirits. At all events, take care that none of the spines be lost, or those of one individual mixed with those of another.

Corals, corallines, and sponges, require merely careful packing, after being sufficiently soaked in fresh water and dried.

Intestinal worms must be carefully sought for in the viscera of every animal the collector kills, and when found, preserved in spirits.

General Remarks.—Every specimen, dry or in spirits, should have a number attached to it, corresponding to one in the collector's note book, in which he must enter his memoranda concerning it, as for instance:

The country where found.
The season when.
Habits.
Habitat.
Local name.

The collector should be furnished with knives, scissors, scalpels, pliers, nets, a large assortment of pins of various sizes, needles, a hammer, small hatchet, packing cases, large and small, including cork boxes for lepidoptera, and a great number of pill boxes in nests, cotton, and paper; and also with a folding net, hoop net, water net, forceps, digger, glass phials, &c. for collecting insects. He must also have a good supply of prussic acid and arsenical soap. The composition and mode of making the latter is as follows:—

Camphor	5 ounces.
Pulverised arsenic	2 lbs.
White soap	2 lbs.
Subcarbonate of potash	12 oz.
Powdered quicklime	4 oz.

Melt the soap completely with the heat, in a small quantity of water, and add the potash and lime; then remove it from the fire and stir in the arsenic: next add the camphor previously rubbed to powder with a little spirit of wine, and mix the whole thoroughly: it should now have the consistence of paste. Preserve it in carefully closed glazed vessels labelled 'POISON.'

To use it, mix the quantity required with cold water, to the consistence of tolerably clear soap, and apply it with a brush to the inside of the skins.

In addition to the above, a small microscope for the examination of infusory animalcules is desirable, and the collector should sketch the forms of all that he observes.

GEOLOGY AND MINERALOGY.

The abrupt termination of cliffs and head lands afford great opportunities of observation and collection. Substances of the most common occurrence should be collected rather than rarities. Specimens should be taken from different parts of each mass. If a rock be composed of different substances, specimens of each should be taken. All specimens should be numbered as soon as possible referring to a list in which all particulars are entered. The relative position of the strata should be recorded, their dip or inclination to the horizon and their direction by compass.

All volcanic appearances should be carefully noted and when marks of recent action are apparent the inhabitants should be questioned as to observed effects. If eruptions are observed, all particulars should be recorded. Specimens of all lavas, obsidian and other volcanic matters should be obtained. The reported site and position of valuable minerals should be noted; these are generally known to the rudest tribes of the east as articles of commerce. The sands of rivers, and coasts, frequently contain metals; they should be examined. All parts of China proper are said to contain coal; enquiry should be made as to the situation of coal mines proximity to naviga-

ble rivers, or to the sea, quality of coal, &c. The clays used in pottery are also of interest, specimens should be obtained.

Fossils should be collected, and the following particulars noted. Place where found. Distance from the sea, river, or lake. Degree of elevation, latitudes and climate. Distance from forest or plain. Indigenous trees or plants. Native animals, depth found. Strata to the part where found. Stratum in which discovered. Position or situation in which it lay. Other discoveries of fossils in the vicinity or other remarks.

Directions for Collecting Specimens of Geology and Mineralogy.

The following short directions being intended for the use of such persons as are supposed to be entirely unpractised in geology and mineralogy, all technical terms, the understanding of which presupposes an acquaintance with those sciences, have been carefully avoided: as, likewise, all references to the relative order of superposition of rocks, and the succession in which many of the materials to be collected are known to be disposed with respect to each other.

1. Common boulders, rolled pieces of rock or their fragments, pebbles, &c. picked up at random, in situations of no peculiar interest, are very seldom of any scientific utility; they had much better be left where they are, than be made the source of embarrassment to those who are expected to arrange and incorporate them with objects of systematic, geological, and mineralogical collections. But boulders, rolled pieces, rubble-stones, and even gravel, sand, silt, and other loose materials, may prove objects of real scientific importance to the intelligent, though unscientific, observer, in proportion as the nature and mode of their occurrence are ascertained, or appear to him to be connected with interesting circumstances and questions: such as their probable origin—whether they may be considered as gradually washed down from higher levels by rains, rivers, &c.—or as remnants of broken up beds of lakes or seas (for

both kinds have often been called indiscriminately alluvial) &c., and he will often find them to contain many interesting remains, teeth and other bones of elephants, hippopotamus, rhinoceros, putrified wood, &c.; also curious mineral substances, such as particles of metallic ores, gems, &c., are frequently found imbedded in those deposits of loose materials: let him carefully collect, label, and preserve such objects. With regard to loose blocks, specimens should in general be detached from such only as from the situation in which they are found, and from other circumstances, have evidently not formed part of the neighbouring masses, and which are therefore called erratic block. Masses of cliffs and rocks precipitated from above at recent periods, may, however often, supply the collector with specimens of strata not easily accessible to him.

Materials for roads, thrown out in heaps, may furnish specimens for collections; but the places from whence they are obtained should be previously ascertained. Road stones are frequently brought from very distant quarries.

2. Upon the whole, rock specimens should be taken fresh from the masses in their native places. Among localities most favourable for this purpose, the following may be specified;—cliffs on the sea shore: they frequently afford very perfect sections of the masses and strata of rocks; precipitous sides of rivers and their beds, and of mountain streams, which often lay open strata and beds at depths otherwise difficult to discover; ravines and deep valleys traversely crossing the strata, and the naked sides of which, especially when long operated upon by rivers and mountain torrents, often present instructive profiles of stratification; artificial sections of grounds, such as are produced by quarries, gravel pits, and excavations of every description for roads, canals, tunnels, wells, &c.

3. Where mines are worked, the collector will generally find some well informed persons or other to assist him in his pursuits; but he should use circumspection in making purchases of specimens from the common miners.

4. Not unfrequently one and the same mass of rock exhibits great diversity of aspect through the variation which takes place in the mixture and proportion of its component ingredients, their colour, &c. Also the texture, such as the crystalline, granular, the slaty, the compact, &c. are subject to variation, and gradual changes have often taken place through atmospheric influence, sometimes to a considerable depth in the mass. Accidental admixtures not essential to the rock are likewise frequently observable. As in such cases a few specimens would convey but an imperfect idea of the true character of the stratum, or other mass of rocks, suites of specimens should be formed, illustrative of most of the varieties which it affords.

5. The thickness of each stratum or bed, and other circumstances connected with them, such as their horizontality or inclination, and the angle under which, and toward what part of the compass they should be regularly noted. Slight sketches of the stratification of a coast or cliff, marked with numbers corresponding to those on the labels of the specimens obtained from those strata, will be found greatly to abbreviate the trouble of writing descriptions on the spot.

6. Examine all places where coal pits are sunk through different strata; procure specimens of these, and likewise of the different varieties of coal, paying particular attention to specimens of vegetable impressions, which they or any of the accompanying rocks, such as sandstone, &c. may afford.

7. No opportunity should be neglected to procure secondary fossils of every description, accompanied by specimens of the masses in which they are imbedded, and which are not seldom chiefly characterised by them. Interest should therefore, everywhere, be made with quarrymen and persons engaged in all sorts of works of excavation, to preserve whatever may be found by them in the way of petrifactions, especially osseous remains; and those persons should be particularly cautioned against breaking to pieces whole skeletons or large

portions of them. If possible, the collector should in person superintend the excavation. The following suggestions, taken from M. De la Beche's excellent treatise, 'How to observe in Geology,' particularly apply to osseous remains of an extremely delicate structure. Instead of endeavouring to extract these on the spot, the observer should detach so much of the rock as shall, to the best of his judgment, envelope the organic remain in a protecting case, valuable for the purpose of transport. Organic remains are generally in better condition, according to the little that is done to them, prior to their final deposit in the museum. If a fossil proves brittle to such a degree that the vibrations produced by blows to its matrix cause it to splinter up, the splinters, if sufficiently large, may be re-adjusted; but it is most advisable, on seeing a fossil begin to splinter, to take some stiff clay, if such can be procured, and press it down upon it. Wax or similar materials might advantageously be employed for this purpose with small specimens. With regard to objects of great rarity and importance, and which rest exposed in a very friable rock, it may even be desirable to prepare plaster of Paris on the spot, and cover the fossil (such as the skeleton of a saurian, &c.) with a thick coating of it. By this process the exposed part of a skeleton is set as it were in a block of plaster, from which, after carefully working beneath it and the fossil in the friable rock, it may afterwards be freed, or in which it may be allowed to remain, as may be desired. When the scattered, yet well preserved fossil bones of an animal are found, it often happens that a large portion of the entire skeleton may be eventually obtained by diligent search. The accidental discovery of a small portion of bone, rising through the rock, may lead to that of the entire skeleton if sufficient care be employed.

In many slaty rocks, fishes, plants, and other organic remains, abundantly occur among the laminæ. In this way multitudes of fossil plants may be obtained of which there were few traces in the cross fracture of the rock.

8. Wherever deposits of secondary fossils are observed, it is of importance to note any striking circumstances relative to their mode of occurring: the proportion, for instance, in which the several species are distributed; whether they are more abundant in one bed of the rock or another; whether they are dispersed in a confused manner through the mass, or arranged parallel to the general stratification, or confined to the surface of any particular stratum; or with regard to their individual position, whether shells for instance, are all exhibiting nearly the same view; or, if fishes affect a general uniform position or parallelism of their sides to the stratification, and such other peculiarities as cannot generally be exemplified even by whole suites of specimens.

9. Uncommonly interesting are the osseous remains of caverns and grottoes, which frequently occur in limestone rocks; these should be diligently sought after and visited, even when report may represent them as not being ossiferous. The collector, in his examination, should proceed systematically by cutting through the layers of the incrustations, which he may find at the bottom of them, and which are formed by the dripping down of water impregnated with calcareous particles: let him form a series of specimens from the layers of this stalagmitic deposit, as likewise of the alluvial matter beneath it, of the gravel, sand, and mud, which usually envelope the osseous remains. Of these latter he should form a complete series—not only as regards the natural difference he may observe in the several bones, likewise the accidental changes observable in them, such as appearance of being gnawed, fractured &c. Also other objects which may be found near to, or accompanying the bones; such as rounded concretions, fragments of stones different from the rock of the cave should be collected, and their manner of occurring noted on the labels. In the same manner, the collector should not neglect recording every circumstance, which the specimens alone are not able to illustrate; such as the distribution of the various bones in the

caverns; their relative abundance, &c. He should also make memoranda relative to the nature and situation of the cavern itself; its direction; its dimensions; the presence or absence of water in it: or whether it be furnished with fissures, particularly vertical ones; and if so, whether these be partly open or filled with bones and rubble cemented together; whether part of the sides near the opening exhibit a polish, as if produced by rubbing against; together with other appearances, which are likely to strike the attentive observer.

If fissures in limestone rocks should on examination prove to be filled with osseous remains, cemented together by calcareous and other matter, it will be desirable, for the purpose of ascertaining whether bones of different animals are found at different depths, to extract them from the lower as well as the higher portions of the fissures, and carefully to note the succession of the several specimens thus obtained.

10. Where petrifying sources as they are called, occur, or waters impregnated with calcareous and other matter thrown down and consolidated into other matter enveloping branches and other parts of vegetables, &c., the collector should, together with specimens, obtain any information within his reach, relative to the condition under which such deposits have been, or continue to be formed in general: it is also desirable chemically to examine such and other waters remarkable for any striking peculiarity. They may readily be transmitted in clean strong bottles, tightly closed, sealed, and labelled.

11. In tracts of country where volcanos are in action, especially if still unexplored by geologists, not specimens only should be collected—but likewise all the historical data that can be obtained relative to the different eruptions and other phenomena connected with them; and all such circumstances should be noted as in any way relate to the nature and appearance of these volcanos; their situation, form, craters, &c.;—together with every particular concerning lava currents; their heat before consolidation; their direction, &c., and perfect suites should be formed of the various volcanic ejections. In

endeavouring to detach specimens from a current of lava, the collector should not confine himself to the upper crust of scoriæ, but likewise obtain fragments from the middle and lower beds. Ashes and other pulverulent volcanic matter are best preserved in strong bottles. Where they are found to inclose organic or other objects, these should be particularly attended to.

12. With regard to certain other rocks, to which the term trappean is applied, and which are now likewise generally considered as igneous, or as having been propelled when in a state of fusion through various rocks which they overlie, the collector, under the supposition that he is not altogether unacquainted with some of those rocks, such as basalt and porphyry, is desired to direct his attention to any alteration that may be observable in the condition of the strata in immediate contact with them. These conditions relate to change of color, lustre, texture, partial fusion or vitrification, &c.; and many of them may be illustrated by suites of specimens, carefully and judiciously selected.

13. An enumeration of the several instruments required by the geological traveller, for determining the direction and inclination of the strata, for measuring heights, &c., as likewise those for mineralogical investigation, would be superfluous to the proficient in geology and mineralogy, and of no avail to the less scientific collector, who, if he wish for information, is necessarily referred to treatises on those sciences. It is however otherwise as regards that indispensable instrument, the hammer. Two of these are at least required; one weighing from two to four pounds and a half, for breaking masses; the other, of smaller dimensions for trimming and fashioning the specimens. Common hammers are not fit for the purpose; they should be well-tempered steel, and handle of very tough wood, and most firmly inserted in the heads.

A few mason's tools or chisels, and a small miner's pick may likewise be occasionally found useful. A glove of thick leather for the left hand, on which the specimens are trimmed, and for their conveyance a bag (likewise of leather), thin, and

cartridge paper for packing, small pieces of paper ready cut for labels, and paste or thick gum water to affix the numbers to the specimens, constitute, together with wool and cotton for delicate and secondary fossils, minerals, &c., all the apparatus that is needful to those who undertake the task of collecting.

14. No particular rules can be given for the operation of breaking, trimming and fashioning rock specimens; but the skilful management of the hammer, though some patience and practice be required, is by no means of difficult acquisition.

Specimens intended for public collections, generally speaking, should be of rather large dimensions: some masses, especially compound rocks, such as conglomerates, &c. cannot, in all their characteristic parts, be studied from diminutive fragments. A convenient size is four to four and a half by three inches, and three quarters of an inch to one inch in thickness. Regularity of shape considerably facilitates the proper and safe packing of the specimens. Trim and fashion them on the spot where there is abundance of materials; the last blow with your hammer will sometimes spoil a specimen. All the surfaces must exhibit a fresh fracture, except where it is desirable to illustrate disintegration through atmospheric and other influences; in which case more than one specimen should be obtained.

15. Each object should have its number affixed by means of gum water or paste, and be accompanied by a ticket on which the exact locality is given; together with such information as the specimen alone is not calculated to give, the nature of the mass from which it is taken, whether in district concretions, columnar, &c.; or, if stratified, the thickness of the stratum, its inclination to the horizon, &c. The numbers on the specimens may, at the same time, correspond to those of the notes of his road book, if such be kept by the collector.

16. Great care should be bestowed on the proper packing of the objects. Each specimen is to be wrapped up in two papers; the inner soft and less substantial than the outer. Put at the bottom of the packing case a layer of hay, chaff,

moss, or other soft substance perfectly dry. Place on it the specimens edgewise, and in close contact with each other; so that nothing can displace them. Fill up the interstices with moss or tow, and place the other specimens in the same manner, layer upon layer, until the box is nearly full, when the remaining vacuities are closely filled up with the same moss, &c., before the lid is fastened. The use of saw dusk for this purpose is not to be recommended. Loose fragile shells and other small delicate objects are best packed by putting them, enveloped in cotton, in rows, and rolling these up in sheets of stiff paper.

17. Still greater care is to be bestowed on such mineralogical specimens as present delicate crystallizations These, after being wrapped up loosely in silk paper, should be put separately into a chip box each, and the empty space filled up with cotton. The chip boxes are to be placed at the bottom of the packing case. Minerals, not soft or brittle, may be wrapped up and packed nearly in the same manner as geological specimens. They are to be placed upright in rows, one above the other, and with their principal surfaces parallel to two opposite sides of the packing case. The weight of such case for land carriage or shipping should not exceed one hundred weight.

18. As the geological collector cannot be expected to discover in his excursions, many specimens of simple minerals desirable to be placed in his collection, he will do well, if he fall in with persons acquainted with, and in the habit of procuring such, to secure their services, with, a view to obtain all mineral substances that are peculiar to any particular tract of country, or else claim attention on the score of their superior beauty and perfection of crystallization. This latter character should particularly be attended to: it is however to be observed that minerals not presenting it may nevertheless prove highly interesting in other respects, and that a remarkable locality alone may often lead importance to a mineral which is abundantly met with at home.

MANNERS, CUSTOMS, &c.

Enquire as to the inhabitants of islands and places visited. whether of Chinese, Malay, or other origin. Their particular customs, religious ceremonies, their progress in agriculture, and the mechanical arts. Intercourse with China or with other nations. Languages, vocabularies should be made at all small and remote islands, amongst mountain tribes, on the main land, and in general amongst all people differing from the Chinese. The vocabularies should be made on some common system of orthography, such for instance as that which Sir William Jones applied to the Indian languages. The names of remarkable natural objects, parts of the human body, deities and other objects of veneration should be taken down first. In China the mechanical arts should be observed, and every thing remarkable recorded. Their models of ships and boat building, method of fastening, making water tight bulkheads, caulking, &c., are all peculiar and deserve examination. The woods used in the construction of their implements, and their comparative durability as reported on by the Chinese. The sailing properties of their vessels, from their very peculiar form, are deserving of being ascertained by trials when practicable, noting the form of the plane of flotation and of the extremities of any vessel that may be tried. Some of their contrivances for turning, and working in ivory, and tortoise shell should be accurately described.

COMMERCE.

Enquiries should be made as to the quantity of tea produced, the proportion which the export bears to that consumed in the country, the prices at various ports as compared to those of Canton. Silk,—we have no accurate imformation as to the mode of cultivation, whether it is produced in

one annual crop or in periodical bunds as in India: the quantity produced, local consumption, prices &c.

Cotton,—quantity produced in China; qualities preferred, prices &c.

Rice,—quantity imported annually and from where; ports chiefly requiring supplies.

Saltpetre, being a prohibited article, whether in much demand, at the eastern ports, or if produced at any particular place, its quality and price.

Metals,—enquiries about the mines should be made, especially as to the precious metals. The mode of working, quantity, produced, capability of extension prices current, &c.

Samples and prices current should be procured of all the woollen, cotton and other fabrics used for dress; quality, price quantity considered, seasons of the year when in demand &c. Also of the *yarns* spun in China, price &c. samples of articles of hardware, tools, agricultural implements &c. should be collected with every information as to price, demand &c.

Pottery of all sorts should be examined, prices enquired and specimens obtained of such as are in general use.

All other articles of commerce should be noted with every particular. The Chinese oil plant *Camelia Oleifera* should be examined and seed obtained in a large quantity that they may be tried as an article of commerce.

The above directions will point out the general spirit in which it is wished that enquiries should be made. Many subjects of research may arise not alluded to herein; it is not intended that they should be overlooked. Too much cannot be observed, collected and recorded; what is superfluous can easily be omitted when the whole body of information thus obtained, shall we brought together, examined, and arranged.

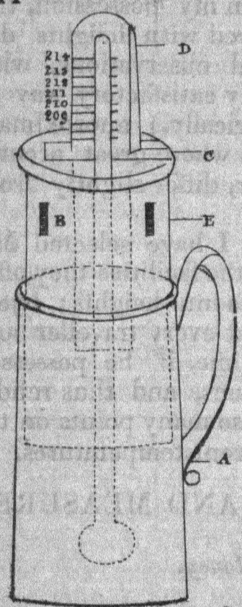
BENGAL SECRETARIAT LIBRARY.

APPENDIX.

On the use of Common Thermometers to determine Heights.
By Lieut. Col. Sykes.

Having been recently applied to by two gentlemen about to travel—the one in Africa and the other in Asia Minor—for a description of the thermometers and apparatus used by myself for some years in India for determining heights by the boiling temperature of water, I have ventured to believe that a brief account of a process which I found to produce results sufficiently near to the truth for most practical purposes, may not be unacceptable particularly as I carried on my barometrical observations contemporaneously, and thereby obtained data for fixing the value of certain points on the thermometric scale. To determine heights accurately, good barometers are necessary, which have been carefully compared with a standard barometer; the observations must be taken simultaneously at the upper and lower stations, and the temperature of the mercury and the air, and the hygrometric state of the latter, must be noted. Heights so determined, when tested again in the same or succeeding years, I have rarely found to vary more than 10 or 20 feet in 4000 or 5000. When barometers are used which have not been previously compared with a standard, when the observations are not simultaneous, and when the pressure and temperature at the level of the sea are *assumed*, the results may by accident be near to the truth, but they will usually be from 100 to 300 feet wrong,—at least such is the result of my experience within the tropics. But good barometers are very costly; they are troublesome to carry, are particularly exposed to accident on a journey, and get out of order by the escape of the mercury, which being frequently unobserved, the barometer continues to be used as if it were correct. The late Archdeacon Wollaston, aware of these facts, invented the thermometric barometer to supply the place of the ordinary barometer. This instrument is very sensible, but it is very fragile from the great weight of the bulb compared with the slenderness of the stem; moreover, there are some complex accompaniments, and the instrument is also expensive: in short, I found it not fit for *rough work* out-of-doors, having had three destroyed at the outset of my labours; and the same

opinion is expressed by Mr. James Prinsep, of Calcutta, who is well known for the practical application of his scientific knowledge. I had then recourse to common thermometers, and, with certain precautions in their use, found them answer my purpose sufficiently well. A tin shaving-pot was my boiler; dry sticks and pure water were usually to be had, and by the time my barometers were settled I was ready to take the boiling temperature. The following is a sketch of the apparatus.



A, A common tin-pot, 9 inches high by 2 in diameter.

B, A sliding tube of tin moving up and down in the pot; the head of the tube is closed, but has a slit in it, C, to admit of the thermometer passing through a collar of cork which shuts up the slit where the thermometer is placed.

D, Thermometer, with so much of the scale left only as may be desirable.

E, Holes for the escape of steam.

It will be seen that the chief part of the scale usually attached to the thermometer is removed, only so much of it being left as may be desirable: I however permitted the brass scale of one of my thermometers to remain, and I did not discover that it was the cause of error. Previously to taking the thermometers inland, it is necessary to ascertain their boiling points at the level of the sea; for in many instances the scales are so carelessly applied, that a thermometer may indicate a boiling temperature of 213° 214° or 215° at the level of the sea; one of mine stood at 214.2 when water boiled. Nevertheless, by making a deduction of 2° 2 in all observations, the indications rarely differed five-hundredths of a degree from the other thermometer, of which the boiling point was 212°: the temperature of the air and the height of the barometer at the time the *verification* of the thermometers is made must be noted. The following is the manner in which my observations were taken:—from 4 to 5 inches of *pure* water were put into the tin pot; the thermometer was fitted into the aperture in the lid of the sliding-tube by means of a collar of cork; the tin tube was then pushed up or down to admit of the bulb of the thermometer, being about *two inches*, above the bottom of the pot. Violent ebullition was continued for 10 minutes or a quarter of an hour, and the height of the mercury was repeatedly ascertained during that time, and the temperature of the air, was noticed. Similar opera-

tions were repeated with a *second* thermometer, for it is never safe to rely upon *one* instrument. Having obtained the boiling points, it remains to determine the value of the indication of diminished pressure when the observations are taken above the level of the sea. The elastic tension of steam at different points on the thermometric scale has been determined by experiment, but not at regular intervals on the scale, nor with similar results, by different persons; tables, therefore, computed from the formulæ of the various experiments do not accord; but, in three tables which I have in my possession, the heights computed by them, when compared with heights determined by corresponding barometrical observations, with previously compared barometers, (the only satisfactory way to ascertain heights not taken trigonometrically,) approximate sufficiently near for all practical purposes where great accuracy is not desired. These tables, however, differ slightly from each other.

Of the three tables* in my possession I have selected Mr. Prinsep's, both for their perspicuity and the facilities they offer for the conversion of boiling temperatures into heights; I join with Mr. Prinsep in expressing a hope that every traveller boiling his thermometers will at the same time, if he possess a barometer, make a record of its indications, and thus render the scale of service to physics by fixing so many points on the essential elastic tension of steam at different temperatures.

TABLES OF MONEY, WEIGHTS, AND MEASURES.

China.—Weights and Money.

10 hwŭh	make	a sze †		
10 sze	——	a haou†		
10 haou	——	a le	or cash.	
10 le †	——	a fun	or candareen.‡	
10 fun	——	a tseën	or mace.	
10 tseen	——	a leang	or tael.	[dupois.
16 leang	——	a kin	or catty=1⅓	lb.avoir-
100 kin	——	a tan	or pecul=133⅓	lbs.
7 mace 2 can.	——	a Spanish Dollar §		

* See tables at the end of pamphlet.

† These terms are also applied to designate the parts of a dollar: haon is a tenth, and sze a hundredth part.

‡ In money, the value of the candareen varies from 10 to 13 or 14 copper cash, and hence the mace varies from 100 to 140, and the dollar from 720 to 1000 cash; but in weight, whether of silver or of any other article, the le or cash always continues the same integral part of a candareen.

§ This is the general estimate, made by the Government, and the bazaar change for dollars, to small amount, 7 mace 2 candareen being the full weight of a good and unmutilated dollar: but in consequence of the system, adopted by all Chinese merchants and shopkeepers, of stamping every dollar they pay out, the weight very speedily diminishes, until the Dollar is eventually broken into pieces, in which state it is melted into sycee.

As the Chinese have no gold or silver coins, but make payments in those metals by weight, this table applies equally to money and to weights of all kinds, excepting that, in money reckonings, nothing higher than the leang or tael is employed. The only coined money the Chinese have is the le or cash. It is made of a very base alloy of copper, is round, about the size of an English farthing, and has a square hole in the middle, by which a hundred or more are usually strung together: on one side are Chinese characters, denoting the reign under which the cash was cast; and on the other side, in those of the present dynasty, are either Chinese or Mantchou characters, designating the place of coinage. Under preceding dynasties, two, five, and ten cash pieces have been in use, as well as other coins of various descriptions; but the single cash is the only coin now current throughout the Empire. It is cast also in Japan, Corea, and Cochin-China; and is clandestinely imported from the last-named place, to a large amount.

Canton Currency.

The circulating medium at Canton, is broken Spanish Dollars, by weight; the relation of which to a tael varies, in different transactions, according to long established usage. In accounts between foreigners and Hong merchants, taels are converted into dollars, at the rate of 720 taels per 1000 dollars; but payments, between these parties, take place at 717 taels per 1000 dollars. Payments, generally, take place at the same rate, of 717 taels per 1000 dollars, with the following exception:—

Payments into the Company's treasury are at	Ts. 718 p. 1000	Drs.
Payments for Bengal Opium are also at.....	718 p. 1000	„
But for Malwa or Turkey, at.....	717 p. 1000	„
Outside merchants, unless it be otherwise specially agreed, receive payments at.....	715 p. 1000	„
As do also ship and house compradors.		

All dollars, though they may be of the same weight, are not received alike by the Chinese. At Soochow, in the Province of Keansoo, and the neighbouring districts, the old Carlos dollars are taken in preference to those of a more modern date, and in consequence are sometimes sought for at Canton, at a premium of 1½ to 4 and even 6 per cent. On the other hand, there is a description of dollars (distinguished from the usual dollars by the letter G. being stamped on them, being coined at the Guadalajara mint) which the Chinese will not receive,

except at a small discount; hence they are called *Kowtseen*, i. e. discounted dollars. The inferiority of these dollars has been fixed by an order of the Hoppo, dated May 1825: they are now, however rarely heard of. The dollars of the Independent Spanish American States do not pass among the Chinese, but are usually taken at par by foreigners, for exportation to India.

The Chinese are very particular in examining all money which passes through their hands: they are also very expert in passing off bad or light money, especially in the payment of small change, of half and quarter dollars, (under which latter name a small proportion of shillings are circulated; sixpences also circulate as eighths of a dollar). One of their most common methods of cheating in weight, is by extracting a small piece of silver from the centre of the dollar, and filling up its place with lead, which they then disguise by repeated stamps.

Weights.

In China, almost every thing is sold by weight, not excepting even liquids and live stock. The only weights are those already given above, the principal of which are the pecul, catty, and tael, divided thus :—

16 taels make a catty.
100 catties——a pecul.

At Macao, the pecul is distinguished by the Portuguese into three kinds, viz.

The pecul balança of 100 catties = 133⅓ lbs. avoirdupois.
The pecul seda of 111-15 do. = 148 1-5th lbs; and
The pecul chapa of 150 do. = 200 lbs.
90 Catties seda = a Canton pecul or pecul balança.

By the first, are sold cotton and valuable articles; by the second, alum, pepper, and coarse goods, and by the third, rice.

In transactions between one Chinese and another, goods are weighed by the Chinese dotchin or balance, which is about 3 per cent less than the English weights; the latter are always used in transactions with foreigners.

Note. At the money standard of 120 oz. 16 dwts. English troy weight for 100 taels, the pecul, which contains 1600 taels, should weigh avoirdupois lbs. 132·535. The actual standard of the pecul being 133⅓ lbs., a slight discrepancy thus appears between the *money* tael and the *commercial* tael, at the stand-

ards assigned to each. But no such difference is recognized by the Chinese. This is noticed to account for what will otherwise appear erroneous in some of the following tables.

Measures.—1. *Long Measure.*

10 fun	or parts make	a tsun	or punt.
10 tsun or punts	——	a chih	or covid= 14⅝ inches.
10 chih or covids	——	a chang	= 4 yds, nearly.
10 chang	——	a yin	

The above are employed in the measurement of all kinds of piece-goods, &c. as well as of every description of workmanship. The following are employed in measuring distances.

5 chih or covids	make	a poo	or pace= 5½ ft. nearly *
360 poo or paces	——	a le	or Chinese mile=659¼yds
250 le or miles	——	a too	or degree on the Equator.

The Chih, covid, or foot is of several varying lengths: according to Milburne, that of the mathematical academy is about 13⅛ English inches; that of the tribunal of Public works 12·7 inches; and that employed by tailors and tradesmen, 13⅓ inches. None however, of these three, is the same as the ordinary covid of Canton, used both in the measurement of vessels, and by tradesmen, which is about 14⅝ inches. The le or mile, is likewise a very uncertain measure of length, varying in almost every part of the Country. It also, like the European geographical mile, forms an integral part of a degree, whether of Latitude or Longitude. But the scientific division of the degree, derived from the European Missionaries, is into 60 fun, or minutes, the fun being divided into 60 meaou or seconds.

II. Land Measures.

5 chil or covids	make	a poo	or kung.
240 poo or kung	——	a mow	or acre.
100 mow or acres	——	a king	

This is the present established land measure, which varies considerably from that formerly in use. In scientific calculations, the mow is divided into ten fun , and the fun into 24 le , and so on, through the several fractional terms which have been already given, at the commencement of the

* This being according to the measure of the mathematical academy differs from the preceding statement.

table of weights. The poo or pace, also, is divided decimally the same terms, fun, le, &c., being employed.

III. Measure of Contents.

6 suh	make	a kwei	.			
10 kwei	——	a chaou	.			
10 chaou	——	a tsuy	.			
10 tsuy	——	a chŏ	.			
10 chŏ	——	a hŏ	.			
10 hŏ	——	a shing	=	31⅔	cubic	punts.
10 shing	——	a tow	=	316	„	„
5 tow	——	a hwŏ	=	1580	„	„
2 hwŏ	——	a shih	=	3160	„	„

This is the scientific division, established by the reigning dynasty. The common measures are,

2 yŏ	make	a hŏ
10 hŏ	——	a shing, or pint.
10 shing	——	a tow.
10 tow	——	a hwŏ.

This table is employed almost exclusively in the measurement of grain; all other articles and even liquids being sold by weight. In dealings with foreigners, however, and probably, also, in large dealings among themselves, the Chinese sell rice and other grain by the catty and pecul weight, instead of the shing, tow, &c. In the sale of paddy, two thirds are allowed for the trouble and diminution in weight, which accompany the taking off the husk, or, which is the same thing, paddy is sold at one third the price of the same weight of rice.

Numbers.

Though not properly included among the subjects now treated of, may be, not inappropriately, here given. The ten units are the following:

At full length.	*Common form*	*Contracted*	*Canton.*		*Fokien*
1,	Yih	—	yat.	yit,*	*chit.*
2,	Urh	—	ee.	je,	*no.*
3,	San	—	sam.	sam,	*sna.*
4,	Sze		se.	soo,	*se.*
5,	Woo		ing.	ngoe,	*goe.*
6,	Lew		luk.	leuk,	*lak.*

* In the Fokien provincial dialect, characters have two pronunciations, the reading, and the spoken or colloquial. The pronunciations here printed in italics are the colloquial.

7,	Tseih	tsat,	chit,	*chit.*
8,	Pă	pat.	pat,	*păyh.*
9,	Kew	kow.	kew,	*kaou.*
10.	Shih	shap.	sip,	*chap.*

The Chinese term for expressing 100 is pih ; 1000, tsëen ; 10,000 wan ; 1,000,000, pih wan, 'a hundred myriads ;' 100,000,000, yih, &c., —progressing decimally through the terms chaou, king, hae, te jang kow, këen, ching, & tsae To express 12, 13, &c. the words or figures 10 and 2, 10 and 3 are put together ; thus shih-urh, 12 ; shih-san, 13, &c. Also urh-shih-yih, 'two tens and one,' denotes 21, &c.

In China almost every trade has a distinct system of secret numbers, that is, instead of using the proper characters for designating prices, they adopt other characters, by which they arbitrarily express their meaning, so as to be understood only by persons of the same trade.

The Chinese method of computing is by a kind of abacus, which they call a Swan-pwan, 'counting board.' It consists of a frame of wood, of various size, divided into two unequal compartments, by a bar, placed crosswise, at about one third the length from the top. Through this bar, at right angles, are inserted a number of parallel wires, and on each wire, in the lower compartment, are five moveable balls, and in the upper, two. These wires may be considered as the ascending and descending powers of a numeration table, proceeding in decimal proportion; so that if a ball, on any of the wires in the larger compartment, be placed against the middle bar, and called unity or one, a ball, on the next wire above it, will represent ten, and one on the next, one hundred : so also, a ball on the wire next below that expressing unity, will be one tenth, and on the next lower, one hundredth : and the balls on the corresponding wires in the smaller compartment, will, in the same manner, represent five, fifty, five hunbred,—five tenths, five hundredths, &c. the value or power of each of those in the smaller division being always five times as much as of those in the larger.

FOR DETERMINING ALTITUDES WITH THE BAROMETER.

Thermometers in open air lower t upper t'				Thermometers to the Barometers.		Latitude of the place.	
$t+t'$	A	$t+t'$	A	$\tau-\tau'$	B	φ	C
40°	4·76891	102°	4·79860	0°	0·00000	0°	0·00117
42	4·76989	104	4·79953	1	0·00004	5	0·00115
44	4·77089	106	4·80045	2	0·00009	10	0·00110
46	4·77187	108	4·80137	3	0·00013	15	0·00100
48	4·77286	110	4·80229	4	0·00017	20	0·00090
50	4·77383	112	4·80321	5	0·00022	25	0·00075
52	4 77482	114	4·80412	6	0·00026	30	0·00058
54	4·77579	116	4·80504	7	0·00030	35	0·00040
56	4·77677	118	4·80595	8	0·00035	40	0·00020
58	4·77774	120	4·80687	9	0·00039	45	0·00000
60	4·77871	122	4·80777	10	0·00043	50	9·99980
62	4·77968	124	4·80869	11	0·00048	55	9·99960
64	4·78065	126	4·80958	12	0·00052	60	9·99942
66	4·78161	128	4·81048	13	0·00056	65	9·99925
68	4·78257	130	4·81138	14	0·00061	70	9·99910
70	4·78353	132	4·81228	15	0·00065	75	9·99900
72	4·78449	134	4·81317	16	0·00069	80	9·99890
74	4·78544	136	4·81407	17	0·00074	85	9·99885
76	4·78640	138	4 81496	18	0 00078	90	9·99883
78	4·78735	140	4·81585	19	0·00083		
80	4·78830	142	4·81675	20	0·00087	Make D equal to log. β — (logβ' + B): then will the logarithm of the difference of altitudes in English feet be equal to A + C + log D	
82	4·78925	144	4·81763	21	0·00091		
84	4·79019	146	4·81851	22	0·00096		
86	4·79113	148	4·81940	23	0·00100		
88	4·79207	150	4·82027	24	0·00104		
90	4·79301	152	4·82116	25	0·00109		
92	4·79395	154	4·82204	26	0·00113		
94	4·79488	156	4·82291	27	0·00117		
96	4·79582	158	4·82379	28	0·00122		
98	4·79675	160	4·82466	29	0·00126		
100	4·79768	162	4·82553	30	0·00130		

This is a very convenient table for computing, by means of logarithms, the *difference of altitudes with the barometer.* The difference of altitude between the two stations is equal to

$$x = 60345{\cdot}51 \left[1 + {\cdot}001111\,(t+t'-64^\circ) \right]$$

$$\times \text{ log. of } \left[\frac{\beta}{\beta'} \times \frac{1}{1+{\cdot}0001\,(\tau-\tau')} \right] \times \left[1 + {\cdot}002695 \cos. 2\,\varphi \right]$$

In the Table, A denotes the logarithm of the first term expressed in English feet; and C the logarithm of the last term: B denotes the logarithm of $1 + {\cdot}0001\,(\tau-\tau')$. the expansion of air, for one degree of Fahrenheit, has been assumed to be ·0022222, instead of the quantity ·00208333 assumed by M. Biot. The rule for the application of this table is given at the bottom thereof; but it may be useful to remark that the heights of the barometers may be taken in any measure whatever whether in English inches, French metres, or any other scale.

Example.

	upper station	lower station
Therm. in open air . .	$t' = 70{\cdot}4$	$t = 77{\cdot}6$
Therm. to barometer.	$\tau' = 70{\cdot}4$	$\tau = 77{\cdot}6$
Barometer	$\beta' = 23{\cdot}66$	$\beta = 30{\cdot}05$

what was the difference in the height of the two stations?

By referring to the rule at the bottom of the Table, the operation will stand thus:

$$\begin{aligned} B &= 0{\cdot}00031 \\ \log \beta' &= 1{\cdot}37401 \\ \hline & \ 1{\cdot}37432 \\ \log \beta &= 1{\cdot}47784 \\ \hline D &= 0{\cdot}10352 \end{aligned} \qquad \begin{aligned} \log &= 9\ 01502 \\ c &= 0{\cdot}00087 \\ A &= 4{\cdot}81940 \\ \hline 6843{\cdot}7 &= 3{\cdot}83529 \end{aligned}$$

Consequently the difference in the altitudes of the two stations was 6843·7 English feet.

TABLES FOR MEASURING HEIGHTS BY THERMOMETER.

Table 1.

To find the Barometric Pressure and Elevation corresponding to any observed Temperature of Boiling Water between 214° and 180°

Boiling Point of Water.	Barometer Modified from Tredgold's Formula.	Logarithmic Differences or Fathoms.	Total Altitude from 30 00 in. or the Level of the Sea.	Value of each Degree in Feet of Altitude.
°			Feet.	Feet.
214	31.19		—1013	
		84.3		—505
213	30.59		507	
		84.5		—507
212	30.00		0	
		84.9		+509
211	29.42		+509	
		85.2		511
210	28.85		1021	
		85.5		513
209	28.29		1534	
		85.8		515
208	27.77		2049	
		86.2		517
207	27.18		2566	
		86.6		519
206	26.64		3085	
		87.1		522
205	26.11		3607	
		87.5		524
204	25 59		4131	
		87.8		526
203	25.08		4657	
		88.1		528
202	24.58		5185	
		88.5		531
201	24.08		5716	
		88.9		533
200	23.59		6250	
		89.3		536
199	23.11		6786	
		89.7		538
198	22.64		7324	
		90.1		541
197	22.17		7864	
		90.5		543
196	21.71		8407	
		91.0		546
195	21.26		8953	
		91.4		548
194	20.82		9502	
		91.8		551
193	20.39		10053	
		92.2		553
192	19.96		10606	
		92.6		556
191	19.54		11161	
		93.0		558
190	19.13		11719	
		93.4		560
189	18.72		12280	
		93.8		563
188	18.32		12843	
		94.2		565
187	17.93		13408	
		94.8		569
186	17.54		13977	
		95.3		572
185	17.16		14548	
		95.9		575
184	16.79		15124	
		96.4		578
183	16.42		15702	
		96.9		581
182	16.06		16284	
		97.4		584
181	15.70		16868	
		97.9		587
180	15.35		17455	

The Fourth Column gives the Heights in Feet.

Table 2,

Table of Multipliers to correct the Approximate Height for the Temperature of the Air.

Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.
o		o		o	
32	1.000	52	1.042	72	1.083
33	1.002	53	1.044	73	1.085
34	1.004	54	1.046	74	1.087
35	1.006	55	1.048	75	1.089
36	1.008	56	1.050	76	1.091
37	1.010	57	1.052	77	1 094
38	1.012	58	1.054	78	1.096
39	1.015	59	1.056	79	1.098
40	1.017	60	1.058	80	1.100
41	1.019	61	1.060	81	1.102
42	1.021	62	1.062	82	1.104
43	1.023	63	1.064	83	1.106
44	1.025	64	1.066	84	1.108
45	1.027	65	1.069	85	1.110
46	1.029	66	1.071	86	1.112
47	1.031	67	1.073	87	1.114
48	1.033	68	1.075	88	1.116
49	1.035	69	1.077	89	1.118
50	1.037	70	1.079	90	1.121
51	1.039	71	1.081	91	1.123

Enter with the mean temperature of the stratum of air traversed, and multiply the approximate height by the number opposite, for the true Altitude.

When the thermometer has been boiled at the foot and at the summit of a mountain, nothing more is necessary than to deduct the number in the column of feet opposite the boiling point below from the same of the boiling point above: this gives an approximate height, to be multiplied by the number opposite the *mean* temperature of the air in Table 2, for the correct altitude.

	o		feet.
Boiling point at summit of Hill Fort of Púrumdhur, near Púna	204.2	=	4027
Boiling point at Hay Cottage, Púna .	207.7	=	1690
Approximate height			2337

Temperature of the air above . 75°
Ditto ditto below . 13

Mean 79 = Multiplier 1.098

Correct altitude 2.566 feet.

When the boiling point at the upper station alone is observed, and for the lower the level of the sea, or the register of a distinct barometer is taken, than the barometic reading had better be converted into feet, by the usual method of subtracting its logarithm from 1.47712 (log. of 30 inches) and multiplying by .0006, as the differences in the column of '*barometer*' vary more rapidly than those in the '*feet*' column.

		Feet.
Example.—Boiling point at upper station - -	185°=	14548
Barometer at Calcutta (at 32°) 29·75		
Logar. diff.=1·47712—1·47349=00363×0006=		218
Approximate height - -		14330
Temperature, upper station, 76° } Ditto lower, 84° }	80=multiplier	1·100
Correct altitude - - -		15763

Assuming 30·00 inches as the average height of the barometer at the level of the sea (which is however too much), the altitude of the upper station is at once obtained by inspection of Table 1, correcting for temperature of the stratum of air traversed by Table 2.

ANALYSIS OF MINERAL WATERS.

In examining a mineral water it is of importance to ascertain its specific gravity which gives some insight into the proportion of its saline ingredients.

Subtract the specific gravity of pure water from that of the water examined, and multiply the remainder by 1. 4. The product is equal to the saline contents. Thus suppose the specific gravity of the water=1.079, and that of pure water =1000 then 79×1.4=110.6=saline contents in 1.000 of the mineral water. It is advisable to conjoin this method with the following.

Evaporate a given weight, say 1,000 parts, to dryness, and exposethe residue for 24 hours to a temperature not exceeding 300 upon a platinum capsule; weigh it while warm, and the mean obtained from this and the former experiment will give the proportion of dry saline ingredients within a trifling error. Thus suppose 1000 parts of the above mentioned water give by evaporation 114.4 over residue, then the mean of this and the former quantity=112.5=quantity of saline matter in a dry state (salts deprived of the water of crystallization) existing in the water.

The substances which very ordinarily occur in mineral waters, are the following:—Oxygen, nitrogen, carbonic acid, sulphuretted hydrogen, carbonate of lime, carbonate of magnesia, carbonate of iron, muriate of magnesia, chloride of sodium, sulphate of magnesia, sulphate of soda, and sulphate of lime.

Oxygen and nitrogen exist in the greater number of spring-waters in the proportions constituting atmospheric air, the proportion of nitrogen is however not infrequently predominant. These gases give no peculiar flavour to the water.

Carbonic acid renders water sparkling and effervescent: it is detected by occasioning a precipitate in a green solution of barytes wh ch dissolves with effervescence in dilute muriatic acid. The presence of sulphuretted hydrogen is known by its odour, by the production of a black precipitate on dropping into the water a solution of nitrate of silver; and by the deposition of sulphur and adding a few drops of nitric acid.

The carbonates are dissolved in the water by excess of carbonic acid, and consequently fall upon its expulsion by boiling. Carbonate of lime and magnesia are deposited in the form of a white precipitate. Carbonate of iron occasions the separation of a brown powder and the water is blackened by a few drops of tincture of galls.

The delicacy of galls, as a test for iron, is affected by the presence of certain salts. If the iron be in the state of protoxide, its detection is facilitated by salts with a base of lime, and by alkalies; if in the state of peroxide, lime prevents the action of the test.

Ferrocyanuret of potassium is also a good test to show minute quantities of iron in water, by the blue precipitate which it occasions; its action is aided by previously adding two or three drops of nitric acid to the water.

The presence of chlorides or muriatic salts is indicated on adding sulphate of silver, by a white cloud, insoluble in nitric acid.

The sulphates, when present in water, afford a white precipitate on the addition of nitrate of barytes, which is insoluble in nitric acid. Lime is recognized by a white cloud on dropping oxalate of ammonia into the water, a portion of the precipitate collected upon leaf platinum, and heated before the blow-pipe, may be burned into quick lime.

Magnesia is rendered evident by adding carbonate of ammonia, which throws down the lime, and subsequently dropping on phosphate of soda, which when magnesia is present, carries it down in the form of a granular precipitate of ammoniaco-magnesian phosphate.

Carbonate of soda is known to exist in water when after having been boiled down to half its bulk and if necessary, filtered, it reddens turmeric paper, and restores the blue in litmus reddened by vinegar; it also affords an effervescent precipitate with nitrate of barytes, soluble in dilute nitric acid. This carbonate is incompatible with the soluble salts of lime.

Muriate of lime may also be used to detect the alkaline carbonates, with which it affords a precipitate of carbonate of lime. Carbonate of soda is distinguished from that of potassa, by the latter affording a precipitate in neutral muriate of platinum, which the former does not. Carbonate of ammonia is discoverable by its smell when acted on by caustic fixed alkali or lime, also by its action on test papers.

Silica is detected by evaporating the water to dryness, and boiling the residue in dilute muriatic acid, the silica if present, remains as a white powder not altered by a red heat but instantly fusing with a particle of carbonate of soda.

To detect boracic acid, evaporate to one-eighth the original bulk of the water, and add carbonate of soda as long as it occasions any precipitate; boil and filter. The filtered liquor will contain borate of soda with some other salts of the same basis evaporated to dryness in a platinum crucible and digest the residue in three parts of sulphuric acid, diluted with its bulk of water. If boracic acid be present, it will separate in micaceous crystals.

Alumina has been found in a few mineral waters in the state of a sulphate. It may be separated by the following process; evaporate to dryness, digest in alcohol and redissolve the residue in eight parts of water; filter, add oxalic acid which throws down lime and which being separated, leaves magnesia and alumina in solution. Carbonate of ammonia throws down the alumina and leaves the magnesia.

Pure ammonia throws down both alumina and magnesia. These earths may be separated by solution of potassa which dissolves the former but not the latter.

Manganese is sometimes found in water, but only in very small proportions so as not to amount to more then a trace.

Certain nitrates are occasionally present in water. Nitrate of lime will be taken up from the residue of evaporation by alcohol, and may be decomposed by carbonate of potassa so as to afford carbonate of lime and crystals of nitre.

It sometimes happens that water contains lead, which may be detected by evaporation to one-eighth its bulk, adding a few drops of nitric acid, and then sulphate of soda, which gives a white insoluble precipitate, and sulphurettred hydrogen, which forms a black cloud. These precipitates may be reduced by heating them before the blow-pipe upon charcoal mixed with a little black flux.

If vegetable or animal matter be contained in water, it gives it a brown colour, especially when evaporated. It may be destroyed in the dry residue by igniting it with a small addition of nitrate of ammonia.

Iodine and Bromine must always be sought for in mineral waters. Where they are suspected, the water should be evaporated to dryness, and the residue triturated with a little distilled water, which will take up the iodic and bromic salts, they are recognized by the addition of a solution of starch having previously added a few drops of solution of chlorine: The iodine will turn blue, but if no iodine be present the chlorine will turn the bromine of a yellow tint.

ARSENIC.

Sulphuretted hydrogen ranks as the best test for arsenic. The fluid tested must not be acid or alkaline ; if the former, potash should be added to neutralization, but if the latter, a saturating quantity of acetic acid must be dropped in ; a stream of sulphureted hydrogen is then passed through the solution, and will cause a copious precipitate of a lemon yellow colour. It should be recollected, however, that an excess of the gas will dissolve the sulphuret of arsenic, producing only a milkiness, but which excess, when expelled by heat, will leave a clear liquid and a decided precipitate.

The sulphuret of arsenic may then be put into a tube with black flux and heated. The arsenic sublimes forming a metallic coating in the tube. This many be subsequently oxidated by the application of heat or taken out, and thrown upon redhot coals and will emit a smell resembling that of garlick.

Ammoniacal nitrate of silver. This test throws down a precipitate of a yellow colour, which afterwards becomes brown by exposure to the light.

Ammoniacal sulphate of copper, added to a solution of arsenic, throws down a grass-green precipitate of arsenite of copper.

CORROSIVE SUBLIMATE.

Protochloride of tin, throws down a grayish black precipitate of mercury which will run into globules by the application of slight heat.

Sulphuretted hydrogen, throws down a brownish black precipitate of the sulphuret of mercury. Hydriodate of Potash, throws down a scarlet precipitate of the biniodide of mercury. This although a delicate test when the oxymuriate is unmixed, is prevented acting characteristically by the presence of many salts and acids. Lime water, throws down a lemon yellow powder forming what is known as yellow wash. Caustic potash produces a yellow precipitate. Liquor ammonia throws down a white precipitate.

Galvanic Test. Place some of the suspected fluid on a piece of gold and bring in contact the blade of a pen knife, a

galvamic action is excited and a white spot or amalgam is formed upon the gold.

The application of the Tests supplied to the Analysis of Water.

When *litmus paper* is reddened, acid is indicated in the water; if carbonic the colour will gradually return and when the water is boiled no effect will be produced. Sulphuretted hydrogen gas in water reddens *litmus*, but this may be detected by adding a few drops of a solution of *acetate* of *lead* which will produce a brown precipitate. Paper stained with tumeric is changed to brown by alkalies and earthy carbonates.

Earths and metallic carbonates are precipitated by boiling the water.

Ferrocyanite of potash dropped into water containing iron produces a blue precipitate, and precipitates all the other metals in their respective colours.

Sulphuric acid, combined or free, is indicated in water by a few drops of nitrate of byrates or solution of acetate of lead each of which forms precipitates. Muriatic acid is detected by Nitrate of silver, a few drops of the solution of which occasionsa white cloud, but alkalies or alkaline carbonates must first be saturated should they exist try a few drops of Nitric acid in which the precipitates should bei nsoluble.

Evaporate a small portion of the water, and examine the residuum; if an acid substance, its nature may be ascertained by the instructions for detecting poisons.

With regard to minerals, tests are believed to be altogether unnecessary, nor does it signify much at the time of collecting them whether you have the means of determining their nature or not, as they will keep and can be examined afterwards at leisure.

THE END.